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PCT/JP2005/002194

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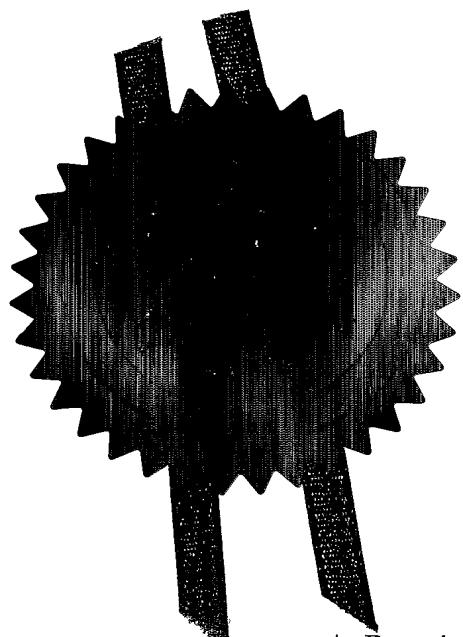
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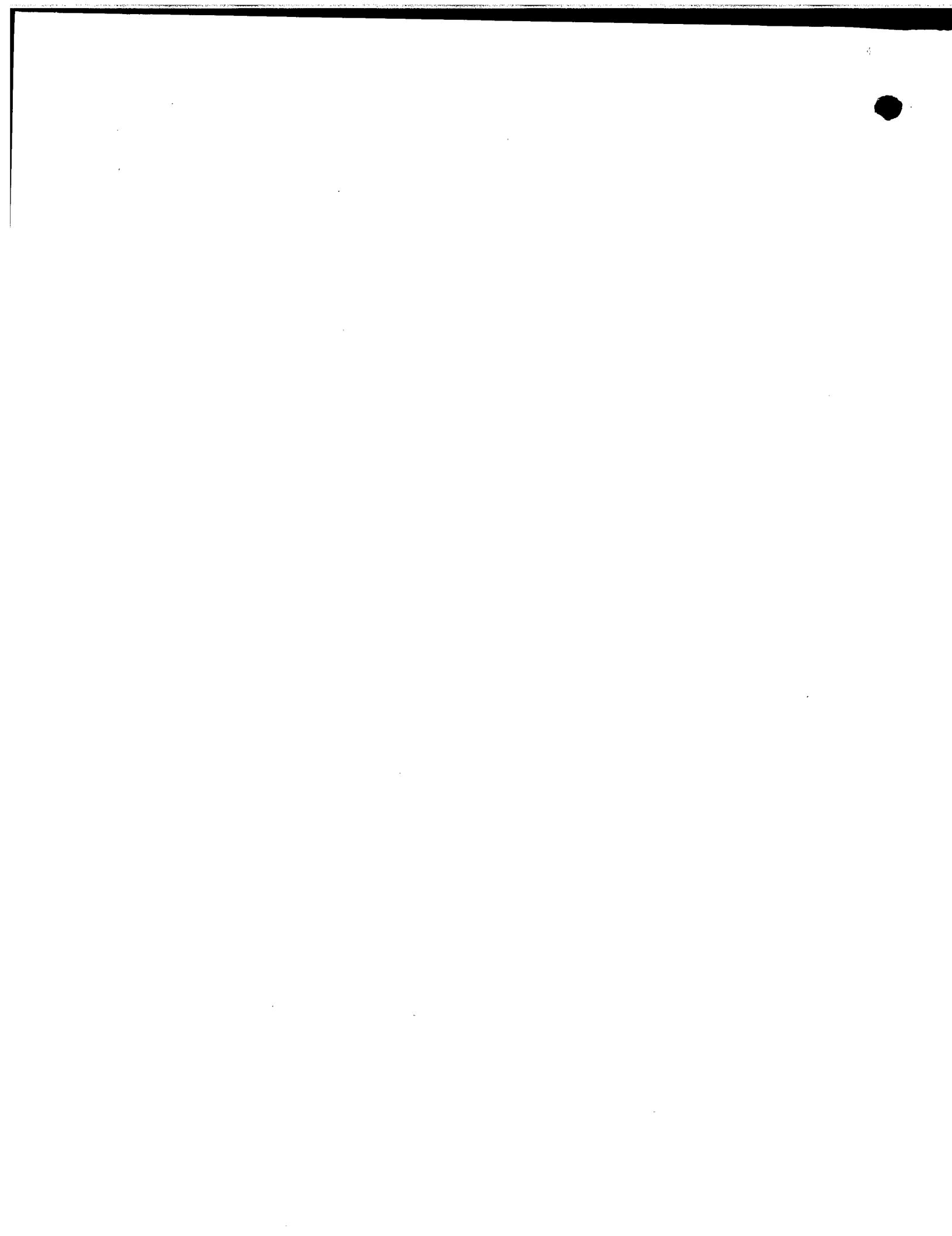
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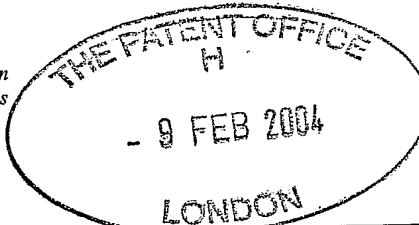
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P01/7700 0.00-0402812-2 NONE1 / 77
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09 FEB 2004

1. Your Reference

ADS/PB60737P

0402812.2

2. Patent application number

(The Patent office will fill in this part)

3. Full name, address and postcode of the or of each applicant (underline all surnames)

Tanabe Seiyaku Co Ltd
2-10 Doshō-Machi 3-Chome
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Japan

Patents ADP number (if you know it)

758987003

If the applicant is a corporate body, give the country/state of its corporation

Japan

4. Title of the invention

NOVEL COMPOUNDS

5. Name of your agent (if you have one)

N Helen Quillin

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

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6. Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months

Country

Priority application number
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7. Divisionals: etc Complete this section only if this application is a divisional application or resulted from an entitlement dispute (see note f)

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8. Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request?

YES

Answer YES if:

- a) any applicant named in part 3 is not an inventor, or
- b) there is an inventor who is not named as an applicant, or
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Patents Form 1/77

9. Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:

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Description	37	✓
Claim(s)	5	✓
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10. If you are also filing any of the following, state how many against each item

Priority Documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patent Form 9/77)

Request for substantive examination (Patent Form 10/77)

Any other documents (please specify)

11. I/We request the grant of a patent on the basis of this application

HELEN QUILLIN

pp Andrew D. Stane

Date: 9 FEBRUARY 2004

01 438 76 8599

12. Name and daytime telephone number and e-mail address, LESLEY WELLS

if any, of person to contact in the United Kingdom

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Novel Compounds

The present invention relates to novel compounds, processes for their preparation, compositions comprising them and their use in the treatment of diseases capable of being modulated by the inhibition of cell adhesion. More particularly the present invention relates to novel heterocyclic compounds that inhibit α_4 integrin mediated cell adhesion and which are useful for the treatment of chronic inflammatory diseases.

The multiple adhesive interactions between leukocytes and endothelial cells or extracellular matrix proteins are a key factor in the regulation of immunity and inflammation. The earliest events in the migration of leukocytes out of the vasculature at the site of inflammation include leukocyte rolling followed by changes in integrin avidity, which lead to subsequent firm adhesion (for reviews see Butcher, *Cell* 67:1033-1036 (1991); Harlan, *Blood* 3:513-525 (1985); Hemler, *Annu. Rev. Immunol.* 8:365-400 (1990); Osborn, *Cell* 62:3-6 (1990); Shimizu et al., *Immunol. Rev.* 114:109-143 (1990); Springer, *Nature* 346:425-434 (1990); and Springer, *Cell* 76:301-314 (1994)). In response to chemotactic factors, the leukocytes migrate through two adjacent endothelial cells and into tissues that are composed, in part, of the extracellular matrix protein fibronectin (FN) (see Wayner et al., *J. Cell Biol.* 105:1873-1884 (1987)) and collagen (CN) (see Bornstein et al., *Ann. Rev. Biochem.* 49:957-1003 (1980); and Miller, Chemistry of the collagens and their distribution, in "Extracellular Matrix Biochemistry", K.A. Piez and A.H. Reddi, editors, Elsevier, Amsterdam, 41-78 (1983)). Important recognition molecules that participate in these adhesive reactions belong to the integrin gene superfamily (for reviews see Hemler, *Annu. Rev. Immunol.* 8:365-400 (1990); Hynes, *Cell* 48:549-554 (1987); Shimizu et al., *Immunol. Rev.* 114:109-143 (1990); and Springer, *Nature* 346:425-434 (1990)).

Integrins are heterodimers composed of non-covalently associated subunits, referred to as the alpha (α) and beta (β) subunits. To date, 8 integrin β subunits have been identified which can associate with 18 distinct α subunits to form 24 distinct integrins (see Hynes, *Cell* 110: 673-687 (2002)).

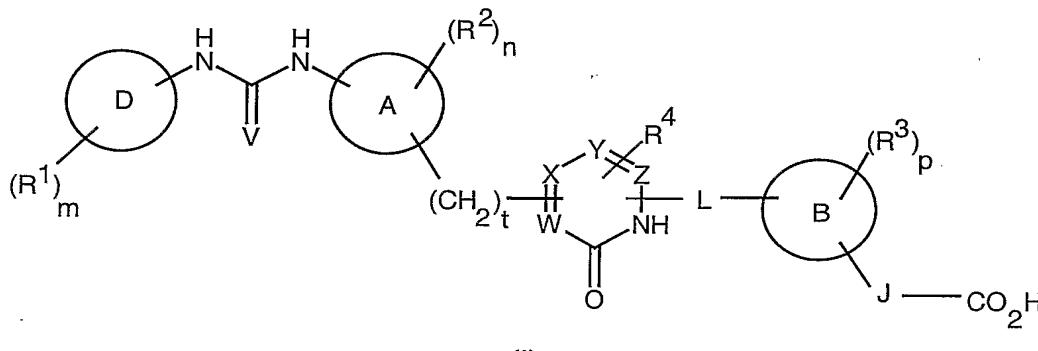
The $\alpha_4\beta_1$ integrin, also known as VLA-4 (Very Late Antigen-4), is constitutively expressed on the surface of leukocytes including lymphocytes, monocytes, eosinophils and basophils (see Hemler et al., *J. Bio. Chem.* 262:11478-11485 (1987); and Bochner et al., *J. Exp. Med.* 173:1553-1556 (1991)). VLA-4 is reported to be present on neutrophils from septic patients (see Ibbotson et al., *Nature Med.* 7:465-470 (2001)). VLA-4 binds to vascular cell adhesion molecule-1 (VCAM-1) on activated endothelial cells, resulting in

extravasation of leukocytes (Elices et al., *Cell* 60:577-584 (1990)). Once the cells have reached the extravascular space, VLA-4 can bind to the connecting segment 1 (CS-1), an alternatively spliced region of the FN A chain (Wayne et al., *J. Cell Biol.* 109:1321-1330 (1989)). In addition, VLA-4 is known to bind to osteopontin, a protein upregulated in 5 arteriosclerotic plaques (see Bayless et al., *J. Cell Science* 111:1165-1174 (1998)).

Patent application PCT/JP03/10119 discloses a series of pyridone compounds that inhibit α_4 integrin mediated cell adhesion and which are useful for the treatment of chronic inflammatory diseases.

10

A novel series of compounds has now been found which also inhibit α_4 integrin mediated cell adhesion. The present invention therefore provides, in a first aspect, a compound of formula (I) or a pharmaceutically acceptable derivative thereof:



15

wherein

- A, B and D are independently aryl or heteroaryl;
- R¹, R² and R³ are independently C₁₋₆alkyl, halogen, C₁₋₆alkoxy, hydroxy, cyano, CF₃, 20 OCF₃, nitro, C₁₋₆alkylthio, amino, mono- or di-C₁₋₆alkylamino, carboxy, C₁₋₆alkanoyl, amido, mono or di-C₁₋₆alkyl amido, NHCOR⁹ or NHSO₂R⁹ in which R⁹ is C₁₋₆alkyl, C₃₋₇cycloalkyl or phenyl (optionally substituted by up to three groups selected from C₁₋₆alkyl, halogen, C₁₋₆alkoxy, cyano, phenyl and CF₃) or is a group -E-(CH₂)₁₋₆NR^XR^Y in which E is a single bond or -OCH₂- and R^X and R^Y are independently hydrogen, C₁₋₆alkyl or combine together to form a 5 - 7 membered heterocyclic ring;
- R⁴ is hydrogen, C₁₋₆alkyl, halogen or C₁₋₆alkoxy;
- V is O, S, NH, N-C₁₋₆alkyl, NNO₂ or NCN;
- W, X, Y and Z are independently C, CH or N, subject to the proviso that at least one of X, Y and Z is N;
- 30 L is -(CH₂)^q- or -(CH₂)^qO- where q is 0, 1, 2 or 3 and q' is 2 or 3;

J is (i) a group $-CR^5_{} = CR^6_{} -$ where $R^5_{} - R^6_{} -$ are independently hydrogen or C_1-6 alkyl;

5 (ii) a group $-CHR^7_{} - CHR^8_{} -$ where $R^7_{} - R^8_{} -$ are independently hydrogen, C_1-6 alkyl, C_3-7 cycloalkyl, aryl, heteroaryl, a group $-NHCOR^9_{} -$ or $-NHSO_2R^9_{} -$ in which $R^9_{} -$ is as defined above or a group $-(CH_2)_1-6NR^X_{}RY_{} -$ in which $R^X_{} - R^Y_{} -$ are as defined above;

(iii) a single bond;

(iv) $-CHR^6_{} -$ where $R^6_{} -$ is as defined above;

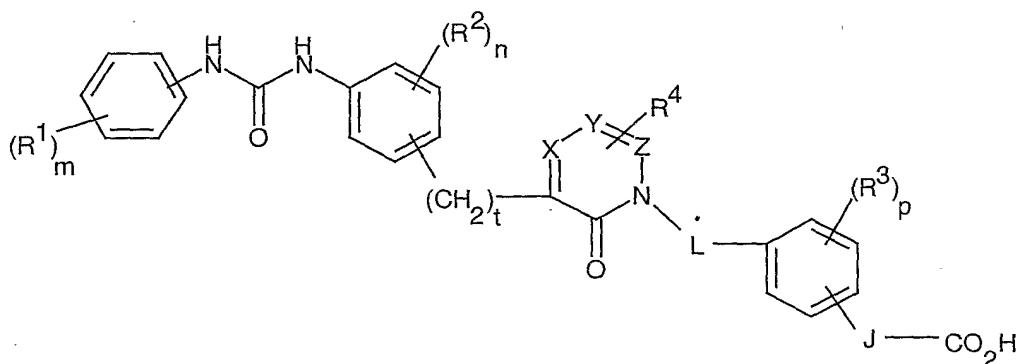
10 (v) a group $-O-CHR^{10}_{} -$, $-NR^{11}_{} - CHR^{10}_{} -$ or $-CR^{12}_{}R^{13}_{} - CHR^{10}_{} -$ where $R^{10}_{} -$ and $R^{11}_{} -$ are independently hydrogen or C_1-6 alkyl and $R^{12}_{} - R^{13}_{} -$ combine together to form a C_3-7 cycloalkyl or a 5 - 7 membered heterocyclic ring;

m, n and p are independently 0, 1, 2 or 3; and

t is 0, 1 or 2.

15

A particularly preferred sub-class of the compounds of formula (I) are the compounds of formula (Ia) or a pharmaceutically acceptable derivative thereof:



20

(Ia)

wherein:

$R^1 - R^4, L, J, X, Y, Z, m, n, p$ and t are as defined in formula (I).

Throughout the present specification, unless otherwise stated:

25 the term "halogen" is used to describe a group selected from fluorine, chlorine, bromine and iodine;

the term "C₁₋₆alkyl" is used to describe a group or a part of the group comprising a linear or branched alkyl group containing from 1 to 6 carbon atoms; examples of such groups include methyl, ethyl, propyl, isopropyl, n-butyl, isobutyl, tert-butyl,

30 pentyl or hexyl;

the term "aryl" is used to denote phenyl and naphthyl (naphth-1-yl and naphth-2-yl) groups;

5 the term "heteroaryl" is intended to mean an aromatic or a benzofused aromatic ring containing 1 to 3 heteroatoms selected from oxygen, nitrogen and sulphur. Suitable examples of such aromatic rings include thienyl, furyl, pyrrolyl, triazolyl, imidazolyl, oxazolyl, thiazolyl, oxadiazolyl, isothiazolyl, isoxazolyl, thiadiazolyl, pyridonyl, pyrazolyl, pyrimidinyl, pyridazinyl, pyrazinyl and pyridyl. Suitable examples of such benzofused aromatic rings include quinolyl, isoquinolyl, indolyl, benzofuranyl, benzothienyl, benzimidazolyl and benzoxazolyl;

10 the term "5 - 7 membered heterocyclic ring" is intended to mean a non-aromatic heterocyclic ring comprising 1 - 3 heteroatoms selected from nitrogen, oxygen and sulphur. Suitable examples of such rings include piperidyl, piperazinyl, pyrrolidinyl and morpholinyl and the like. The heterocyclic rings are optionally substituted by C₁₋₆alkyl;

15 the term "C₁₋₆ alkoxy" is used to describe a group or a part of the group wherein an oxygen atom is bound to the above-mentioned alkyl group; examples of such groups include methoxy, ethoxy, propoxy, isopropoxy, butoxy, isobutoxy, sec-butoxy and tert-butoxy, pentoxy or hexoxy;

20 the term "C₁₋₆ alkanoyl" is used to describe groups formed by removing a "OH" group from the carboxyl group of a C₁₋₆ carboxylic acid; examples of such groups include formyl, acetyl, propionyl or butyryl;

the term "C₃₋₇ cycloalkyl" means a cyclic C₃₋₇ alkyl group; examples of such groups include cyclohexyl or cyclopentyl;

25 When A, B and/or C is aryl a preferred group is phenyl. When A, B and/or C is heteroaryl a preferred group is pyridyl.

30 Suitably, A is phenyl or pyridyl.

Suitably, B is phenyl.

Suitably D is phenyl or pyridyl.

35 Suitably, R¹, R² and R³ are independently C₁₋₆alkyl, halogen, C₁₋₆alkoxy, hydroxy, cyano, CF₃, nitro, C₁₋₆alkylthio, amino, mono- or di-C₁₋₆alkylamino, carboxy, C₁₋₆alkanoyl, amido, mono or di-C₁₋₆alkyl amido, NHCOR⁹ or NHSO₂R⁹ in which R⁹ is C₁₋

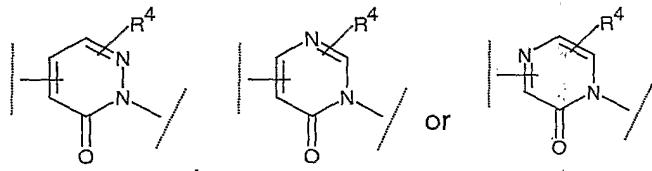
6alkyl, C₃-7cycloalkyl or phenyl (optionally substituted by up to three groups selected from C₁-6alkyl, halogen, C₁-6alkoxy, cyano, phenyl or CF₃) or is a group -E-(CH₂)₁₋₆NR^XRY in which E is a single bond or -OCH₂- and RX and RY are independently hydrogen, C₁-6alkyl or combine together to form a ring including piperidinyl, piperazinyl, 5 pyrrolidinyl or morpholinyl group in which a ring is optionally substituted by C₁-6alkyl.

Preferably R¹, R² and R³ are, independently, selected from the group consisting of C₁-6alkyl, halogen, C₁-6alkoxy, cyano and CF₃.

10 When m, n or p is other than 0, preferred R¹, R² and R³ groups respectively include C₁-6alkyl (particularly methyl), halogen (particularly fluoro or chloro) or C₁-6alkoxy (particularly methoxy or ethoxy).

15 When m, n or p is 2 or 3, the groups R¹, R² and R³ respectively can be the same or different.

Preferably V is O.



Preferably the ring containing W, X, Y, Z is

in which the ring nitrogen adjacent to the carbonyl is bonded to the group L.

20 Suitably, R⁴ is hydrogen or halogen. Preferably R⁴ is hydrogen.

Suitably L is -(CH₂)_q- where q is 0, 1, 2 or 3. Preferably L is -CH₂-.

25 Suitably, J is (i) a group -CR⁵ = CR⁶- where R⁵ and R⁶ are independently hydrogen or C₁-6alkyl;
 (ii) a group -CHR⁷-CHR⁸- where R⁷ and R⁸ are independently hydrogen, C₁-6alkyl, C₃-7cycloalkyl, phenyl, naphthyl, thienyl, furyl, pyrrolyl, triazolyl, imidazolyl, oxazolyl, thiazolyl, oxadiazolyl, isothiazolyl, isoxazolyl, thiadiazolyl, pyridonyl, pyrazolyl, pyrimidinyl, pyridazinyl, pyrazinyl, pyridyl quinolyl, isoquinolyl, indolyl, benzofuranyl, benzothienyl, benzimidazolyl, benzoxazolyl, a group -NHCOR⁹- or -NHSO₂R⁹- in which

R⁹ is as defined above or a group -(CH₂)₁₋₆NR^XRY- in which R^X and R^Y are as defined above;

5 (iii) a single bond;
(iv) -CHR⁶- where R⁶ is as defined above;
(v) a group -O-CHR¹⁰-, -NR¹¹-CHR¹⁰- or -CR¹²R¹³CHR¹⁰- where R¹⁰ and R¹¹ are independently hydrogen or C₁₋₆alkyl and R¹² and R¹³ are independently C₁₋₆alkyl or R¹² and R¹³ combine together to form phenyl, C₃₋₇ cycloalkyl, piperidyl, piperazinyl, pyrrolidinyl or morpholinyl.

10. Preferably J is
(i) a group -CR⁵ = CR⁶- where R⁵ and R⁶ are independently hydrogen or C₁₋₆alkyl; or
(ii) a group -CHR⁷-CHR⁸- where R⁷ and R⁸ are independently hydrogen, C₁₋₆alkyl or a group -NHCOR⁹- or -NHSO₂R⁹- in which R⁹ is as defined above.

15

Most preferably, J is selected from the group consisting of -CH = CH-, -(CH₂)₂-, -CHR⁷-CH₂- in which R⁷ is C₁₋₆alkyl (particularly methyl or ethyl).

20. Particularly preferred compounds of this invention are selected from the group consisting of E1 - E12 (as described below) or a pharmaceutically acceptable derivative thereof.

25. It will be appreciated that the compounds of formula (I) have one or more asymmetric carbon atoms and therefore may occur as racemates, racemic mixtures and as individual enantiomers or diastereomers. All such isomeric forms are included within the present invention, including mixtures thereof.

30. Where a compound of the invention contains an alkenyl or alkenylene group, cis (Z) and trans (E) isomerism may also occur. The present invention includes the individual stereoisomers of the compound of the invention and, where appropriate, the individual tautomeric forms thereof, together with mixtures thereof.

35. Separation of diastereoisomers or cis and trans isomers may be achieved by conventional techniques, e.g. by fractional crystallisation, chromatography or HPLC. A single stereoisomeric form of the compound may also be prepared from a corresponding optically pure intermediate or by resolution, such as HPLC of the corresponding racemate using a suitable chiral support or by fractional crystallisation of the diastereoisomeric salts

formed by reaction of the corresponding racemate with a suitable optically active acid or base, as appropriate. Alternatively a mixture of enantiomers may be separated by chemical reaction with an appropriate chiral compound with the formation of a new covalently bonded species, for example the coupling of a racemic carboxylic acid with a 5 chiral amine or alcohol to give a diastereomeric mixture (in the case of amides or esters respectively), which may be separated by conventional techniques such as column chromatography, HPLC or fractional crystallisation. The single diastereomers may then be converted to the single enantiomers of the desired compound by appropriate chemistry such as hydrolytic cleavage of the new covalent bond.

10

As used herein, the term "pharmaceutically acceptable derivative", means any pharmaceutically acceptable salt, solvate, or prodrug e.g. ester, of a compound of the invention, which upon administration to the recipient is capable of providing (directly or indirectly) a compound of the invention, or an active metabolite or residue thereof. Such 15 derivatives are recognizable to those skilled in the art, without undue experimentation. Nevertheless, reference is made to the teaching of Burger's Medicinal Chemistry and Drug Discovery, 5th Edition, Vol 1: Principles and Practice, which is incorporated herein by reference to the extent of teaching such derivatives. Preferred pharmaceutically acceptable derivatives are salts, solvates, esters, carbamates and phosphate esters. 20 Particularly preferred pharmaceutically acceptable derivatives are salts, solvates and esters. Most preferred pharmaceutically acceptable derivatives are salts and esters.

Those skilled in the art of organic chemistry will appreciate that many organic compounds 25 can form complexes with solvents in which they are reacted or from which they are precipitated or crystallized. These complexes are known as "solvates". For example, a complex with water is known as a "hydrate". Solvates of the compound of the invention are within the scope of the invention.

As used herein, the term "prodrug" means a compound which is converted within the 30 body, e.g. by hydrolysis in the blood, into its active form that has medical effects. Pharmaceutically acceptable prodrugs are described in T. Higuchi and V. Stella, Prodrugs as Novel Delivery Systems, Vol. 14 of the A.C.S. Symposium Series, Edward B. Roche, ed., Bioreversible Carriers in Drug Design, American Pharmaceutical Association and Pergamon Press, 1987, and in D. Fleisher, S. Ramon and H. Barbra 35 "Improved oral drug delivery: solubility limitations overcome by the use of prodrugs", Advanced Drug Delivery Reviews (1996) 19(2) 115-130, each of which are incorporated herein by reference.

Prodrugs are any covalently bonded carriers that release a compound of formula (I) in vivo when such prodrug is administered to a patient. Prodrugs are generally prepared by modifying functional groups in a way such that the modification is cleaved, either by 5 routine manipulation or in vivo, yielding the parent compound. Prodrugs include, for example, compounds of this invention wherein hydroxy or amine groups are bonded to any group that, when administered to a patient, cleaves to form the hydroxy or amine groups. Thus, representative examples of prodrugs include (but are not limited to) acetate, formate and benzoate derivatives of alcohol and amine functional groups of the 10 compounds of formula (I). Further, in the case of a carboxylic acid (-COOH), esters may be employed, such as methyl esters, ethyl esters, double esters and the like. Esters may be active in their own right and /or be hydrolysable under *in vivo* conditions in the human body. Suitable pharmaceutically acceptable *in vivo* hydrolysable ester groups include 15 those which break down readily in the human body to leave the parent acid or its salt.

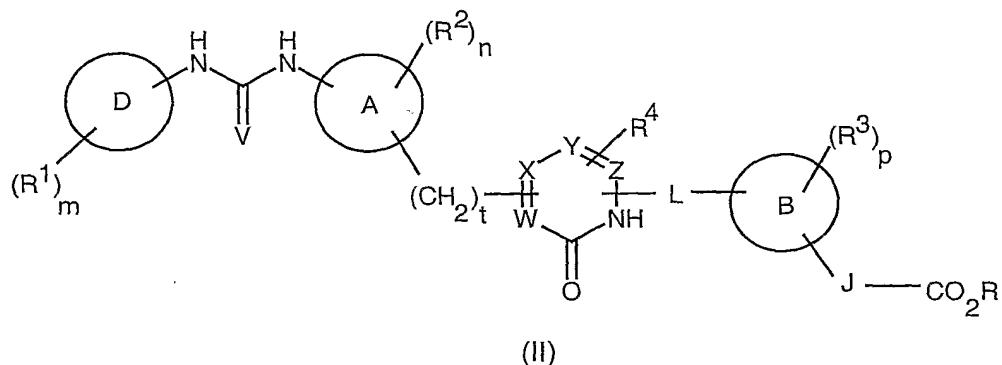
15 The compounds of the present invention may be in the form of and/or may be administered as a pharmaceutically acceptable salt. For a review on suitable salts see Berge et al., J. Pharm. Sci., 1977, 66, 1-19.

20 Typically, a pharmaceutical acceptable salt may be readily prepared by using a desired acid or base as appropriate. The salt may precipitate from solution and be collected by filtration or may be recovered by evaporation of the solvent.

25 Suitable addition salts are formed from acids which form non-toxic salts and examples are hydrochloride, hydrobromide, hydroiodide, sulfate, bisulfate, nitrate, phosphate, hydrogen phosphate, acetate, maleate, malate, fumarate, lactate, tartrate, citrate, formate, gluconate, succinate, piruvate, oxalate, oxaloacetate, trifluoroacetate, saccharate, benzoate, methanesulfonate, ethanesulfonate, benzenesulfonate and p-toluenesulfonate.

30 Pharmaceutically acceptable base salts include ammonium salts, alkali metal salts such as those of sodium and potassium, alkaline earth metal salts such as those of calcium and magnesium and salts with organic bases, including salts of primary, secondary and tertiary amines, such as isopropylamine, diethylamine, ethanolamine, trimethylamine, dicyclohexyl amine and N-methyl-D-glucamine.

In a further aspect, the present invention also provides a process for the preparation of a compound of formula (I) or a pharmaceutically acceptable derivative thereof which comprises hydrolysis of a carboxylic acid ester derivative of formula (II):



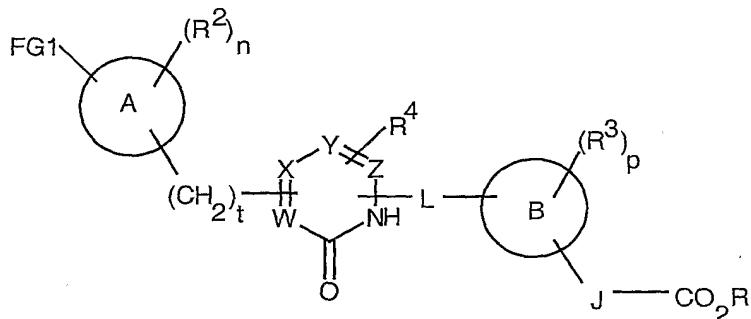
in which $R^1 - R^4$, m , n , p , t , A , B , D , L , J , V , W , X , Y and Z are as defined in formula (I) and R is a group capable of forming a carboxylic acid ester and optionally thereafter forming a pharmaceutically acceptable derivative thereof.

10

An example of a suitable R group is C_{1-6} alkyl such as methyl or t -butyl. Hydrolysis may either occur via an acidic or an alkaline medium. Such methods are familiar to those skilled in the art.

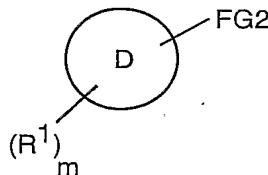
15 The compounds of formula (II) can be prepared by either:

(a) reacting a compound of formula (III)



20

in which $R^2 - R^4$, n , p , t , A , B , L , J , R , W , X , Y and Z are as defined in formulae (I) or (II) with a compound of formula (IV)

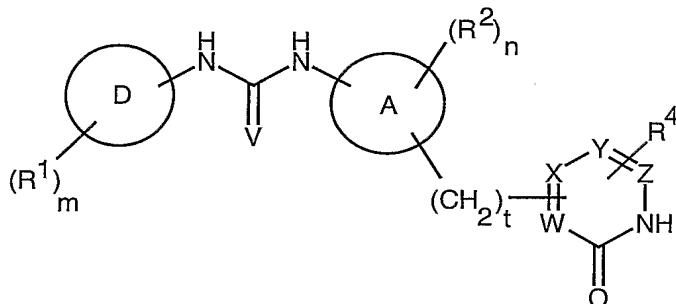


(IV)

in which R^1 , m and D are as defined in formula (I) and $FG1$ and $FG2$ contain appropriate functional groups which are capable of reacting together to form the urea moiety; or

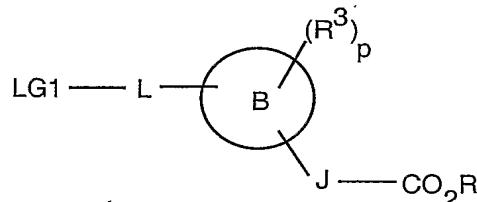
5

(b) reacting the compound of formula (V)



(V)

10 in which R^1 , R^2 , R^4 , m , n , t , A , D , V , W , X , Y and Z are as defined in formula (I) or (II) with a compound of formula (VI)



(VI)

15 in which p , R , R^3 , J , B and L are as defined in formulae (I) or (II) and $LG1$ is a leaving group.

For process (a), suitable examples of appropriate $FG1$ and $FG2$ groups include:

(i) $FG1$ is $-N=C=O$ and $FG2$ is NH_2 ; or $FG1$ is NH_2 and $FG2$ is $N=C=O$; or
 20 (ii) $FG1$ is NH_2 and $FG2$ is NH_2 together with an appropriate urea forming agent.

In process (i) the reaction is typically carried out in an inert solvent such as dichloromethane or acetonitrile at ambient temperature.

In process (ii) the reaction is typically carried out in the presence of an appropriate urea forming agent, such as carbonyl diimidazole or phosgene, a suitable solvent being an inert organic solvent such as dimethylformamide, tetrahydrofuran, or dichloromethane at ambient or elevated temperature optionally in the presence of a base such as 5 triethylamine or pyridine.

For process (b), a suitable example of a leaving group is halogen, particularly chloro or mesylate. The reaction is typically carried out in an inert solvent such as tetrahydrofuran or acetonitrile at ambient temperature.

10 Intermediate compounds of formula (II) are believed to be novel and form a yet further aspect of this invention.

15 Intermediate compounds of formulae (III), (IV), (V) and (VI) are either commercially available or can be prepared using methods described herein, by methods known to those skilled in the art or by analogous methods thereto.

20 Those skilled in the art will appreciate that in the preparation of the compound of the invention or a solvate thereof it may be necessary and/or desirable to protect one or more sensitive groups in the molecule to prevent undesirable side reactions. Suitable protecting groups for use according to the present invention are well known to those skilled in the art and may be used in a conventional manner. See, for example, "Protective groups in 25 organic synthesis" by T.W. Greene and P.G.M. Wuts (John Wiley & sons 1991) or "Protecting Groups" by P.J. Kocienski (Georg Thieme Verlag 1994). Examples of suitable amino protecting groups include acyl type protecting groups (e.g. formyl, trifluoroacetyl, acetyl), aromatic urethane type protecting groups (e.g. benzyloxycarbonyl (Cbz) and substituted Cbz), aliphatic urethane protecting groups (e.g. 9-fluorenylmethoxycarbonyl (Fmoc), t-butyloxycarbonyl (Boc), isopropylloxycarbonyl, cyclohexyloxycarbonyl) and alkyl type protecting groups (e.g. benzyl, trityl, chlorotriyl). Examples of suitable oxygen 30 protecting groups may include for example alky silyl groups, such as trimethylsilyl or tert-butyldimethylsilyl; alkyl ethers such as tetrahydropyranyl or tert-butyl; or esters such as acetate.

35 Compounds of this invention may be tested for *in vitro* biological activity in accordance with the following assay.

Jurkat J6 Scintillation Proximity Assay (SPA)

The Jurkat J6 Scintillation Proximity Assay was used to investigate the interaction of the integrin VLA-4 (Very Late Antigen-4; 41; CD49d, CD29) expressed on the Jurkat J6 cell membrane with test compounds. J6 cells (1 million cells/well) were allowed to coat wheat germ agglutinin coated SPA beads (Amersham, 1mg/well) in assay buffer containing 5 50mM HEPES, 100mM NaCl and 1mM MnCl₂ (pH with 4M NaOH to 7.5). Tritiated 3H Standard Compound A (1-3 nM final assay concentration) and test compounds were dissolved in an appropriate solvent and diluted in assay buffer. Compounds were assayed in duplicate, a four parameter curve fit being applied. The equilibrium dissociation constant for each compound was calculated according to the method of 10 Cheng & Prusoff (Biochem Pharmacol., 22(23) : 3099 - 3108 (1973)). Data were presented as the mean pKi.

Standard compound A is (2S)-3-[4-((4-(aminocarbonyl)-1-piperidinyl)carbonyl)oxy]phenyl]-2-[((2S)-4-methyl-2-[(2-methylphenoxy)acetyl]amino)pentanoyl]amino] propanoic acid potassium salt which is 15 described in patent application WO 00/37444 (Glaxo Group Ltd. et al.). Tritiated 3H derivatives may be prepared employing conventional methods.

All examples prepared in accordance with this invention were tested in accordance with 20 this procedure and were found to have a pKi \geq 7.0.

Compounds of formula (I) or a pharmaceutically acceptable derivatives thereof inhibit α_4 integrin mediated cell adhesion and are believed to be of potential use in the treatment or prophylaxis of such conditions as rheumatoid arthritis (RA); asthma; allergic conditions 25 such as rhinitis; adult respiratory distress syndrome; AIDS-dementia; Alzheimer's disease; cardiovascular diseases; thrombosis or harmful platelet aggregation; reocclusion following thrombolysis; reperfusion injury; skin inflammatory diseases such as psoriasis, eczema, contact dermatitis and atopic dermatitis; diabetes (e.g., insulin-dependent diabetes mellitus, autoimmune diabetes); multiple sclerosis; systemic lupus erythematosus (SLE); 30 inflammatory bowel disease such as ulcerative colitis, Crohn's disease (regional enteritis and pouchitis (for example, resulting after proctocolectomy and ileoanal anastomosis); diseases associated with leukocyte infiltration to the gastrointestinal tract such as Celiac disease, nontropical Sprue, enteropathy associated with seronegative arthropathies, lymphocytic or collagenous colitis, and eosinophilic gastroenteritis; diseases associated 35 with leukocyte infiltration to other epithelial lined tissues, such as skin, urinary tract, respiratory airway, and joint synovium; pancreatitis; mastitis (mammary gland); hepatitis; cholecystitis; cholangitis or pericholangitis (bile duct and surrounding tissue of the liver);

bronchitis; sinusitis; inflammatory diseases of the lung which result in interstitial fibrosis, such as hypersensitivity pneumonitis; collagen disease (in SLE and RA); sarcoidosis; osteoporosis; osteoarthritis; atherosclerosis; neoplastic diseases including metastasis of neoplastic or cancerous growth; wound healing enhancement; certain eye diseases such

5 as retinal detachment, allergic conjunctivitis and autoimmune uveitis; Sjogren's syndrome; rejection (chronic and acute) after organ transplantation; host vs. graft or graft vs. host diseases; intimal hyperplasia; arteriosclerosis (including graft arteriosclerosis after transplantation); reinfarction or restenosis after surgery such as percutaneous transluminal coronary angioplasty (PTCA) and percutaneous transluminal artery 10 recanalization; nephritis; tumor angiogenesis; malignant tumor; multiple myeloma and myeloma-induced bone resorption; sepsis; and central nervous system injury such as stroke, traumatic brain injury and spinal cord injury and Meniere's disease.

15 The compounds of the present invention can be preferably used for the treatment or prevention of asthma, allergic conditions such as rhinitis, inflammatory bowel disease such as ulcerative colitis and Crohn's disease, rheumatoid arthritis, atopic dermatitis, multiple sclerosis and rejection after organ transplantation.

20 The present invention further provides a method for the treatment or prophylaxis of conditions in which an inhibitor of α_4 integrin mediated cell adhesion is beneficial which comprises administering to a patient in need thereof a safe and effective amount of a compound of formula (I) or a pharmaceutically acceptable salt thereof. The present invention especially provides for a method for the treatment or prophylaxis of the aforementioned conditions.

25 The present invention also provides for a compound of formula (I) or a pharmaceutically acceptable derivative thereof for use in therapy, particularly the treatment of the aforementioned disorders.

30 In another aspect, the invention provides the use of a compound of formula (I) or a pharmaceutically acceptable derivative thereof in the manufacture of a medicament for the treatment or prophylaxis of conditions in which an inhibitor of α_4 integrin mediated cell adhesion is beneficial, particularly the aforementioned disorders.

35 While it is possible for the compounds of the present invention to be administered alone, it is preferable to formulate into a pharmaceutical composition in accordance with standard pharmaceutical practice. Thus the invention also provides for a pharmaceutical

composition which comprises a therapeutically effective amount of a compound of formula (I) in admixture with a pharmaceutically acceptable carrier or diluent.

5 The invention further provided for a pharmaceutical composition comprising a compound of formula (I) or a pharmaceutically acceptable derivative thereof together with another therapeutically active agent.

10 There is further provided by the present invention a process of preparing a pharmaceutical composition, which process comprises mixing at least one compound of the invention or a pharmaceutically acceptable derivative thereof, together with a pharmaceutically acceptable carrier or diluent.

15 The pharmaceutical compositions may be for human or animal usage in human and veterinary medicine and will typically comprise any one or more of a pharmaceutically acceptable diluent, carrier or excipient. Acceptable carriers or diluents for therapeutic use are well known in the pharmaceutical art, and are described, for example, in Remington's Pharmaceutical Sciences, Mack Publishing Co. (A. R. Gennaro edit. 1985). The choice of pharmaceutical carrier, excipient or diluent can be selected with regard to the intended route of administration and standard pharmaceutical practice. The carrier or diluent must
20 be acceptable in the sense of being not deleterious to the recipient thereof. The pharmaceutically acceptable carrier or diluent may be, for example, binders (e.g., syrup, gum arabic, gelatin, sorbitol, tragacanth, polyvinylpyrrolidone), excipients (e.g., lactose, sucrose, corn starch, potassium phosphate, sorbitol, glycine), lubricants (e.g., magnesium stearate, talc, polyethylene glycol, silica) disintegrators (e.g., potato starch), wetting
25 agents (e.g., sodium laurylsulfate), and the like.

30 The routes for administration (delivery) of the composition of the invention include, but are not limited to, one or more of: oral (e. g. as a tablet, capsule, or as an ingestible solution), topical, mucosal (e. g. as a nasal spray or aerosol for inhalation), nasal, parenteral (e. g. by an injectable form), gastrointestinal, intraspinal, intraperitoneal, intramuscular, intravenous, intrauterine, intraocular, intradermal, intracranial, intratracheal, intravaginal, intracerebroventricular, intracerebral, subcutaneous, ophthalmic (including intravitreal or intracameral), transdermal, rectal, buccal, epidural, sublingual.

35 For example, the compound can be administered orally in the form of tablets, capsules, ovules, elixirs, solutions or suspensions, which may contain flavouring or colouring agents, for immediate-, delayed-, modified-, sustained-, pulsed- or controlled-release

applications. The tablets may contain excipients such as microcrystalline cellulose, lactose, sodium citrate, calcium carbonate, dibasic calcium phosphate and glycine, disintegrants such as starch (preferably corn, potato or tapioca starch), sodium starch glycollate, croscarmellose sodium and certain complex silicates, and granulation binders

5 such as polyvinylpyrrolidone, hydroxypropylmethylcellulose (HPMC), hydroxypropylcellulose (HPC), sucrose, gelatin and acacia. Additionally, lubricating agents such as magnesium stearate, stearic acid, glyceryl behenate and talc may be included. Solid compositions of a similar type may also be employed as fillers in gelatin capsules. Preferred excipients in this regard include lactose, starch, a cellulose, milk
10 sugar or high molecular weight polyethylene glycols. For aqueous suspensions and/or elixirs, the agent may be combined with various sweetening or flavouring agents, colouring matter or dyes, with emulsifying and/or suspending agents and with diluents such as water, ethanol, propylene glycol and glycerin, and combinations thereof.

15 The compounds of the invention may be milled using known milling procedures such as wet milling to obtain a particle size appropriate for tablet formation and for other formulation types. Finely divided (nanoparticulate) preparations of the compounds of the invention may be prepared by processes known in the art, for example see International Patent Application No. WO 02/00196 (SmithKline Beecham).

20 If the compound of the present invention is administered parenterally, then examples of such administration include one or more of: intravenously, intraarterially, intraperitoneally, intrathecally, intraventricularly, intraurethrally, intrasternally, intracranially, intramuscularly or subcutaneously administering the agent; and/or by
25 using infusion techniques. For parenteral administration, the compounds are best used in the form of a sterile aqueous solution which may contain other substances, for example, enough salts or glucose to make the solution isotonic with blood. The aqueous solutions should be suitably buffered (preferably to a pH of from 3 to 9), if necessary. The preparation of suitable parenteral formulations under sterile conditions is readily
30 accomplished by standard pharmaceutical techniques well-known to those skilled in the art.

As indicated, the compound of the present invention can be administered intranasally or by inhalation and is conveniently delivered in the form of a dry powder inhaler or an
35 aerosol spray presentation from a pressurised container, pump, spray or nebuliser with the use of a suitable propellant, e. g. dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, a hydrofluoroalkane such as 1,1,1,2-tetrafluoroethane (HFA

134AT""") or 1,1,1,2,3,3,3-heptafluoropropane (HFA 227EA) (for example from Inneous Fluor), carbon dioxide or other suitable gas. In the case of a pressurised aerosol, the dosage unit may be determined by providing a valve to deliver a metered amount. The pressurised container, pump, spray or nebuliser may contain a solution or suspension of

5 the active compound, e. g. using a mixture of ethanol and the propellant as the solvent, which may additionally contain a lubricant, e. g. sorbitan trioleate. Capsules and cartridges (made, for example, from gelatin) for use in an inhaler or insufflator may be formulated to contain a powder mix of the compound and a suitable powder base such as lactose or starch.

10

Alternatively, the compound of the present invention can be administered in the form of a suppository or pessary, or it may be applied topically in the form of a gel, hydrogel, lotion, solution, cream, ointment or dusting powder. The compound of the present invention may also be dermally or transdermally administered, for example, by the use 15 of a skin patch. They may also be administered by the pulmonary or rectal routes. They may also be administered by the ocular route. For ophthalmic use, the compounds can be formulated as micronised suspensions in isotonic, pH adjusted, sterile saline, or, preferably, as solutions in isotonic, pH adjusted, sterile saline, optionally in combination with a preservative such as a benzylalkonium chloride. Alternatively, they may be 20 formulated in an ointment such as petrolatum.

For application topically to the skin, the agent of the present invention can be formulated as a suitable ointment containing the active compound suspended or dissolved in, for example, a mixture with one or more of the following: mineral oil, liquid petrolatum, white 25 petrolatum, propylene glycol, polyoxyethylene polyoxypropylene compound, emulsifying wax and water. Alternatively, it can be formulated as a suitable lotion or cream, suspended or dissolved in, for example, a mixture of one or more of the following: mineral oil, sorbitan monostearate, a polyethylene glycol, liquid paraffin, polysorbate 60, cetyl esters wax, cetearyl alcohol, 2-octyldodecanol, benzyl alcohol and water.

30

The compositions of the present invention may be administered by direct injection.

In a preferred embodiment, the agents of the present invention are delivered systemically (such as orally, buccally, sublingually), more preferably orally.

35

Hence, preferably the agent is in a form that is suitable for oral delivery.

Typically, a physician will determine the actual dosage which will be most suitable for an individual subject. The specific dose level and frequency of dosage for any particular individual may be varied and will depend upon a variety of factors including the activity of the specific compound employed, the metabolic stability and length of action of that compound, the age, body weight, general health, sex, diet, mode and time of administration, rate of excretion, drug combination, the severity of the particular condition, and the individual undergoing therapy.

For oral and parenteral administration to humans, the daily dosage level of the agent may be in single or divided doses.

A proposed dose of the compounds according to the present invention for administration to a human (of approximately 70kg body weight) is 0.1mg to 1g, preferably to 1mg to 500mg of the active ingredient per unit dose, expressed as the weight of free base. The unit dose may be administered, for example, 1 to 4 times per day. The dose will depend on the route of administration. It will be appreciated that it may be necessary to make routine variations to the dosage depending on the age and weight of the patient as well as the severity of the condition to be treated. The dosage will also depend on the route of administration. The precise dose and route of administration will ultimately be at the discretion of the attendant physician or veterinarian.

The compounds of the invention may also be used in combination with other therapeutic agents. The invention thus provides, in a further aspect, a combination comprising a compound of the invention or a pharmaceutically acceptable derivative thereof together with a further therapeutic agent.

When a compound of the invention or a pharmaceutically acceptable derivative thereof is used in combination with a second therapeutic agent active against the same disease state the dose of each compound may differ from that when the compound is used alone. Appropriate doses will be readily appreciated by those skilled in the art. It will be appreciated that the amount of a compound of the invention required for use in treatment will vary with the nature of the condition being treated and the age and the condition of the patient and will be ultimately at the discretion of the attendant physician or veterinarian. Examples of other active agents that may be combined with a compound of formula (I) include, but not limited to: (a) other VLA-4 antagonists; (b) H1 histamine antagonists; (c) NSAID's; (d) anti-diabetic agent e.g. glitazones (e) anti-cholinergic agents (f) COX-2 inhibitors; (g) PDE-IV inhibitors; (h) steroids e.g. corticosteroids; (i) beta agonists;

(j) antagonists of the chemokine receptors e.g. CCR-2, CCR-3, CCR-5 and CCR-8; (k) suitable multiple sclerosis agents such as interferon; and (l) LFA-1 antagonists.

The combinations referred to above may conveniently be presented for use in the form
5 of a pharmaceutical formulation and thus pharmaceutical formulations comprising a combination as defined above together with a pharmaceutically acceptable carrier or excipient comprise a further aspect of the invention. The individual components of such combinations may be administered either sequentially or simultaneously in separate or
10 combined pharmaceutical formulations by any convenient route. When administration is sequential, either the compound of the invention or the second therapeutic agent may be administered first. When administration is simultaneous, the combination may be administered either in the same or different pharmaceutical composition.

When combined in the same formulation it will be appreciated that the two compounds
15 must be stable and compatible with each other and the other components of the formulation. When formulated separately they may be provided in any convenient formulation, conveniently in such manner as are known for such compounds in the art.

All publications, including but not limited to patents and patent applications, cited in this
20 specification are herein incorporated by reference as if each individual publication were specifically and individually indicated to be incorporated by reference herein as though fully set forth.

The following Descriptions and Examples illustrate the preparation of compounds of the
25 invention.

Description 1

3-(4-Hydroxymethylphenyl)acrylic acid ethyl ester (D1)

4-Bromobenzyl alcohol (10.5 g, 56.1 mmol), triphenylphosphine (0.5 g, 1.9 mmol) and
30 palladium acetate (0.5 g, 2.2 mmol) were stirred at reflux in ethyl acrylate (20 mL) and triethylamine (100 mL) for 72 hours, then allowed to cool. The reaction mixture was filtered through celite (Diatomaceous Earth), then concentrated. The crude solid was purified by chromatography on silica gel (20% v/v ethyl acetate in petroleum ether) to afford the title compound as an oil.

35

Description 2

3-(4-Hydroxymethylphenyl)propionic acid ethyl ester (D2)

3-(4-Hydroxymethylphenyl)acrylic acid ethyl ester (D1, 3 g, 14.5 mmol) and palladium on charcoal (0.3 g) in ethanol (30 mL) was stirred for 4 hours under atmospheric pressure of hydrogen. The reaction mixture was filtered through celite (Diatomaceous Earth) and concentrated to afford the title compound as an oil.

5 **Description 3**

3-(4-Chloromethylphenyl)propionic acid ethyl ester (D3)

To a stirred solution of 3-(4-hydroxymethylphenyl)propionic acid ethyl ester (D2, 2.9 g, 13.9 mmol) in triethylamine (4.0 mL, 27.8 mmol) and dichloromethane (30 mL) was slowly added at 0°C mesyl chloride (1.6 mL, 20.9 mmol). The solution was stirred at 10 room temperature for 18 hours, then the solution was washed with 1N aqueous hydrochloric acid. The organic phase was dried (anhydrous magnesium sulfate) and concentrated to afford the title compound as an oil.

Description 4

(E)-3-(4-Formylphenyl)but-2-enoic acid ethyl ester (D4)

15 4-Bromobenzaldehyde (12.0 g, 65 mmol), ethyl crotonate (26.0 mL, 209 mmol), triphenylphosphine (0.5 g, 2 mmol) and palladium (II) acetate (0.5 g, 2 mmol) were stirred at reflux under argon for 24 hours. The mixture was then filtered and concentrated *in vacuo* to yield a dark brown oil. This was purified by chromatography on silica gel (0-30% ethyl acetate in hexane, gradient), giving the title compound as an oil; MS (ES+ve): 20 $[\text{M}+\text{H}]^+$ at m/z 219 ($\text{C}_{13}\text{H}_{14}\text{O}_3$ requires $[\text{M}+\text{H}]^+$ at m/z 219).

Description 5

(R,S)-3-(4-Hydroxymethylphenyl)butyric acid ethyl ester (D5)

A mixture of (E)-3-(4-formylphenyl)but-2-enoic acid ethyl ester (D4, 8.74 g, 40 mmol) and 10% palladium on carbon (60% aqueous paste, 0.5 g) was hydrogenated in ethanol 25 (200 mL) at atmospheric pressure for 4 hours. The mixture was filtered through kieselguhr, and the filtrate then concentrated *in vacuo* to give a colourless oil. After purification by chromatography on silica gel (0-60% ethyl acetate in hexane, gradient) the title compound was obtained as a colourless oil; MS (ES+ve): $[\text{M}-\text{OH}]^+$ at m/z 205 ($\text{C}_{13}\text{H}_{18}\text{O}_3$ requires $[\text{M}-\text{OH}]^+$ at m/z 205).

30 **Description 6**

4-[(S)-2-((S)-2-Hydroxy-1-phenylethylcarbamoyl)-1-methylethyl]benzoic acid ethyl ester (D6a) and 4-[(R)-2-((S)-2-hydroxy-1-phenylethylcarbamoyl)-1-methylethyl]benzoic acid ethyl ester (D6b)

To a solution of 4-(2-carboxy-1-methylethyl)benzoic acid ethyl ester (J. I. DeGraw *et al.* *J. Med. Chem.* 1986, 29, 1056) (3.54 g, 15 mmol) in dichloromethane (100 mL) cooled in an

ice bath was added oxalyl chloride (3.9 mL, 45 mmol). Dimethylformamide (0.1 mL) was added and the mixture stirred at room temperature for 2 hours, then concentrated under reduced pressure. The residual acid chloride was dissolved in dichloromethane (60 mL) and added to an ice-cooled mixture of (*S*)-2-phenylglycinol (2.72 g, 20 mmol) and 5 triethylamine (6.3 mL, 45 mmol) in dichloromethane (60 mL) over 30 minutes. The reaction mixture was stirred at room temperature for 1 hour. 2N Hydrochloric acid was added, the organic phase was separated, then washed with water, dried (anhydrous magnesium sulfate) and evaporated. The diastereomeric products were separated by flash chromatography with elution by ethyl acetate, then ethyl acetate-methanol (9:1). There 10 were obtained an earlier eluting diastereomer (D6a); TLC (silica gel; ethyl acetate) R_f 0.36; MS (ES+ve): $[M+H]^+$ at m/z 356 ($C_{21}H_{25}NO_4$ requires $[M+H]^+$ at m/z 356); and a later eluting diastereomer (D6b); TLC (silica gel; ethyl acetate) R_f 0.19; MS (ES+ve): $[M+H]^+$ at m/z 356 ($C_{21}H_{25}NO_4$ requires $[M+H]^+$ at m/z 356)

Description 7

15 (*S*)-3-(4-Hydroxymethylphenyl)-*N*-((*S*)-2-hydroxy-1-phenylethyl)butyramide (D7a) and (*R*)-3-(4-hydroxymethylphenyl)-*N*-((*S*)-2-hydroxy-1-phenylethyl)butyramide (D7b)

To a solution of the later eluting diastereomer, 4-[(*R*)-2-((*S*)-2-hydroxy-1-phenylethylcarbamoyl)-1-methylethyl]benzoic acid ethyl ester, (D6b, 2.42 g, 6.81 mmol) 20 in tetrahydrofuran (100 mL) was added a solution of lithium borohydride in tetrahydrofuran (2M, 15 mL, 30 mmol). Methanol (1 mL) was added dropwise and the reaction mixture stirred at room temperature for 2 hours. A further portion of lithium borohydride in tetrahydrofuran (2M, 10 mL, 20 mmol) and methanol (0.8 mL) were added and the mixture stirred for a further 3 hours, then cooled in an ice bath. 2N Hydrochloric 25 acid (100 mL) was added cautiously, then the mixture was concentrated under reduced pressure. Ethyl acetate was added and the organic phase washed with water, then brine, dried (anhydrous magnesium sulfate) and evaporated to give one diastereomer (D7b) of the title compound; MS (ES-ve): $[M-H]^-$ at m/z 312 ($C_{19}H_{23}NO_3$ requires $[M-H]^-$ at m/z 312).

The other diastereomer (D7a) was prepared in a similar manner from the earlier eluting 30 diastereomer 4-[(*S*)-2-((*S*)-2-hydroxy-1-phenylethylcarbamoyl)-1-methylethyl]benzoic acid ethyl ester (D6a).

Description 8

(*R*)-(-)-3-(4-Hydroxymethylphenyl)butyric acid methyl ester (D8)

To a solution of the diastereomer (*R*)-3-(4-hydroxymethylphenyl)-*N*-((*S*)-2-hydroxy-1-phenylethyl)butyramide (D7b, 2.0 g, 6.38 mmol) in dioxane (85 mL) was added 3N

sulphuric acid (85 mL). The mixture was heated at reflux for 6 hours, cooled and then concentrated under reduced pressure. The concentrate was extracted three times with ethyl acetate, the combined organic phases were washed with water, then brine, dried (anhydrous magnesium sulfate) and evaporated. The residual solid was dissolved in 5 methanol (90 mL) and concentrated sulphuric acid (2 mL) added. The mixture was refluxed for 1 hour, cooled and then concentrated under reduced pressure. Water and ethyl acetate were added and the organic phase was washed with water, then brine, dried (anhydrous magnesium sulfate) and evaporated. Purification by flash chromatography with elution by ethyl acetate-hexane (1:1) gave the title compound as a colourless oil; 10 $[\alpha]_D^{30^\circ\text{C}} -41.2^\circ$ (c = 1.0, MeOH).

Description 9

(S)-(+)-3-(4-hydroxymethylphenyl)butyric acid methyl ester (D9)

The title compound was prepared from the diastereomer D7a in a similar manner to that of Description 8; $[\alpha]_D^{30^\circ\text{C}} +42.4^\circ$ (c = 1.0, MeOH).

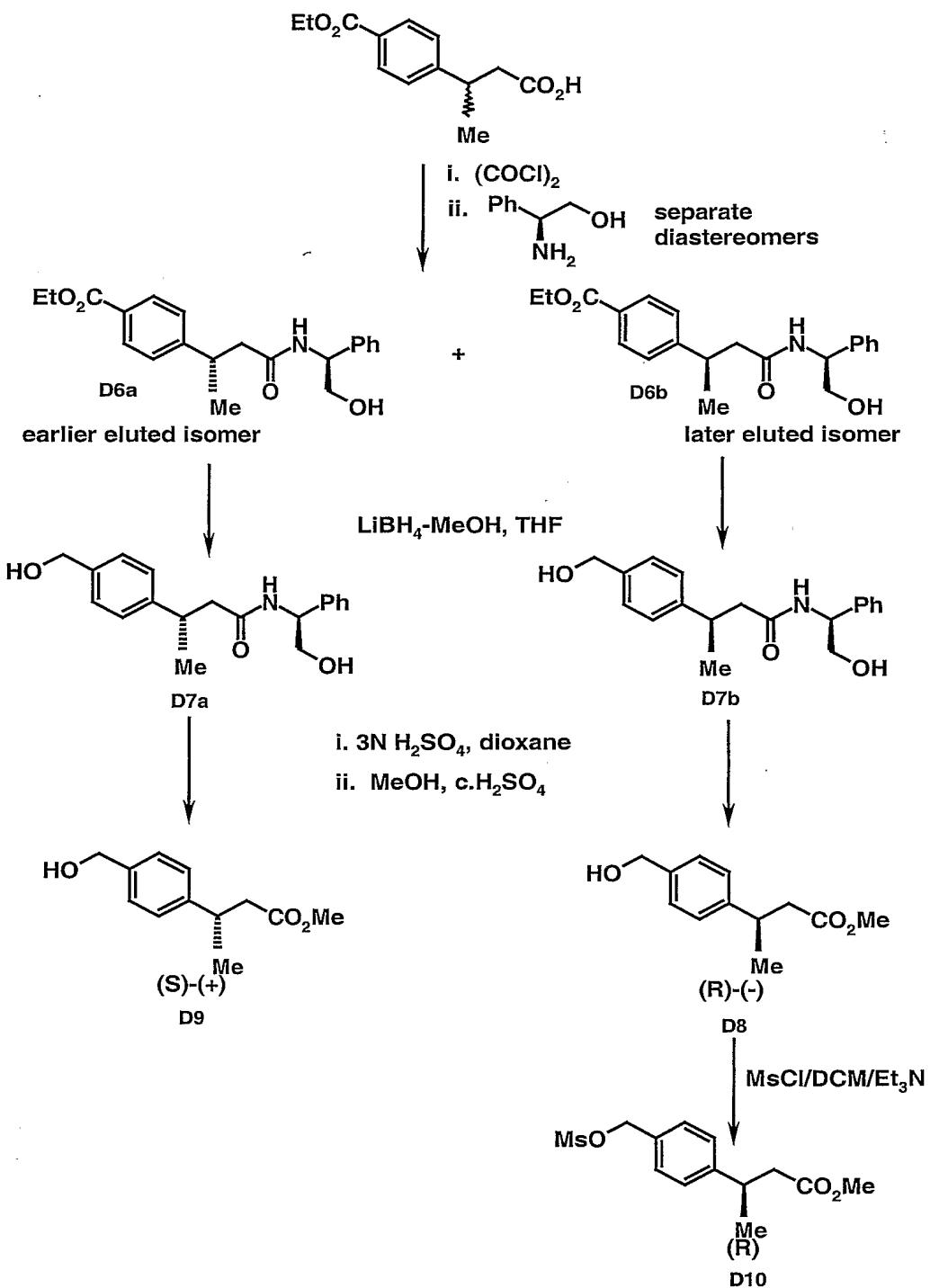
15 **Description 10**

(R)-3-(4-Methanesulfonyloxyethylphenyl)butyric acid methyl ester (D10)

A solution of (R)-(-)-3-(4-hydroxymethylphenyl)butyric acid methyl ester (D8, 400 mg, 1.80 mmol) in dichloromethane (10 mL) was cooled in an ice bath and treated with triethylamine (0.28 mL, 1.99 mmol) and methanesulfonyl chloride (0.15 mL, 1.99 mmol).

20 The reaction was stirred in an ice bath for 1 hour and then the mixture was diluted with dichloromethane and water. After separation of the organic layer the aqueous phase was further extracted with dichloromethane and then the combined organic layers dried over magnesium sulfate. After filtration and evaporation of the solvent the resulting crude product was used directly without further purification.

25 Descriptions D6 - D10 are represented in the following reaction scheme.



Description 11

2-Ethoxy-4-methyl-1-nitrobenzene (D11)

Sodium hydride (60% in mineral oil, 2.30 g, 57 mmol) was stirred under argon in solid carbon dioxide bath cooled dimethylformamide (100 mL) as 2-hydroxy-4-methyl-1-nitrobenzene (8.00 g, 52 mmol) was added in dry dimethylformamide (75 mL) over 10 minutes. The mixture was stirred at ambient temperature for 1 hour, re-cooled in ice, and 5 treated with iodoethane (4.6 mL, 57 mmol). This mixture was stirred at ambient temperature for 5 days, concentrated at reduced pressure, diluted with ethyl acetate (200 mL), washed with water (3 x 200 mL) and brine (200 mL), dried over magnesium sulfate, filtered and concentrated at reduced pressure to yield the title compound. This material was used in the next step without further purification; LC/MS (ES+ve): $[M+H]^+$ at m/z 182 10 ($C_9H_{11}NO_3$ requires $[M+H]^+$ at m/z 182).

Description 12

[(E)-2-(3-Ethoxy-4-nitrophenyl)-vinyl]-dimethylamine (D12)

2-Ethoxy-4-methyl-1-nitrobenzene (D11, 9.26 g, 51 mmol) and *tert*-butoxybis(dimethylamino)methane (20.2 mL, 98 mmol) were heated to 100°C for 16 15 hours, and then concentrated at reduced pressure to yield the title compound. This material was used in the next step without further purification; LC/MS (ES-ve): M^- at m/z 236 ($C_{12}H_{16}N_2O_3$ requires M^- at m/z 236).

Description 13

(3-Ethoxy-4-nitrophenyl)-acetonitrile (D13)

[(E)-2-(3-Ethoxy-4-nitrophenyl)-vinyl]-dimethylamine (D12, 12.10 g, 51 mmol) and hydroxylamine-O-sulfonic acid (17.40 g, 154 mmol) were stirred under argon in water (200 mL) for 5 hours. The title compound was obtained as a solid after filtration and 25 drying. This material was used in the next step without further purification; LC/MS (ES-ve): $[M-H]^-$ at m/z 205 ($C_{10}H_{10}N_2O_3$ requires $[M-H]^-$ at m/z 205).

Description 14

2-(3-Ethoxy-4-nitrophenyl)-acetamide (D14)

(3-Ethoxy-4-nitrophenyl)-acetonitrile (D13, 5.0 g, 190 mmol) was stirred vigorously in concentrated hydrochloric acid (20 mL) for 48 hours. It was then diluted with water (100 mL), and extracted into ethyl acetate (3 x 100 mL). The organic phase was washed with 30 saturated sodium bicarbonate (2 x 100 mL), dried over magnesium sulfate, filtered and concentrated at reduced pressure to yield the title compound. This material was used in the next step without further purification; LC/MS (ES+ve): $[M+H]^+$ at m/z 225 ($C_{10}H_{12}N_2O_4$ requires $[M+H]^+$ at m/z 225).

Description 15

35 **5-(3-Ethoxy-4-nitrophenyl)-3*H*-pyrimidin-4-one (D15)**

2-(3-Ethoxy-4-nitrophenyl)-acetamide (D14, 1.78 g, 8.0 mmol) and *N,N',N''*-methylidynetrisformamide (2.30 g, 16 mmol) were stirred under argon in formamide (3 mL). The mixture was heated to 160°C for 8 hours, diluted with water (25 mL) and treated with 2N aqueous sodium hydroxide (10 mL). It was heated in a steam bath until 5 dissolution occurred, and then treated with charcoal (2.5 g), sonicated and then filtered. Carbon dioxide was bubbled into the filtrate until pH 7 was achieved. The resulting precipitate was filtered, then azeotroped with toluene (3 x 50 mL) to yield the title compound. This material was used in the next step without further purification; LC/MS (ES+ve): [M+H]⁺ at m/z 262 (C₁₂H₁₁N₃O₄ requires [M+H]⁺ at m/z 262).

10 **Description 16**

5-(4-Amino-3-ethoxyphenyl)-3*H*-pyrimidin-4-one (D16)

5-(3-Ethoxy-4-nitrophenyl)-3*H*-pyrimidin-4-one (D15, 830 mg, 3.2 mmol) was stirred under argon in ethyl acetate (50 mL) and ethanol (50 mL). Tin (II) chloride dihydrate (3.59 g, 16 mmol) was added and the mixture was heated at 80°C for 5 hours. Saturated sodium 15 bicarbonate (100 mL) was added and the mixture was filtered, the filtrate was extracted into ethyl acetate (3 x 50 mL), washed with water (2 x 50 mL) and brine (50 mL), dried over magnesium sulfate, filtered and concentrated at reduced pressure to yield the title compound. This material was used in the next step without further purification; LC/MS (ES+ve): [M+H]⁺ at m/z 232 (C₁₂H₁₃N₃O₂ requires [M+H]⁺ at m/z 232).

20 **Description 17**

1-[2-Ethoxy-4-(6-oxo-1,6-dihydro-pyrimidin-5-yl)phenyl]-3-*o*-tolyl-urea (D17)

5-(4-Amino-3-ethoxyphenyl)-3*H*-pyrimidin-4-one (D16, 390 mg, 1.7 mmol) was stirred under argon in dichloromethane (20 mL). *o*-Tolylisocyanate (0.32 mL, 2.5 mmol) was added over 5 minutes, the reaction was stirred for a further 4 hours and then concentrated 25 at reduced pressure to yield the title compound as a solid. This material was used in the next step without further purification; LC/MS (ES+ve): [M+H]⁺ at m/z 365 (C₂₀H₂₀N₄O₃ requires [M+H]⁺ at m/z 365).

Description 18

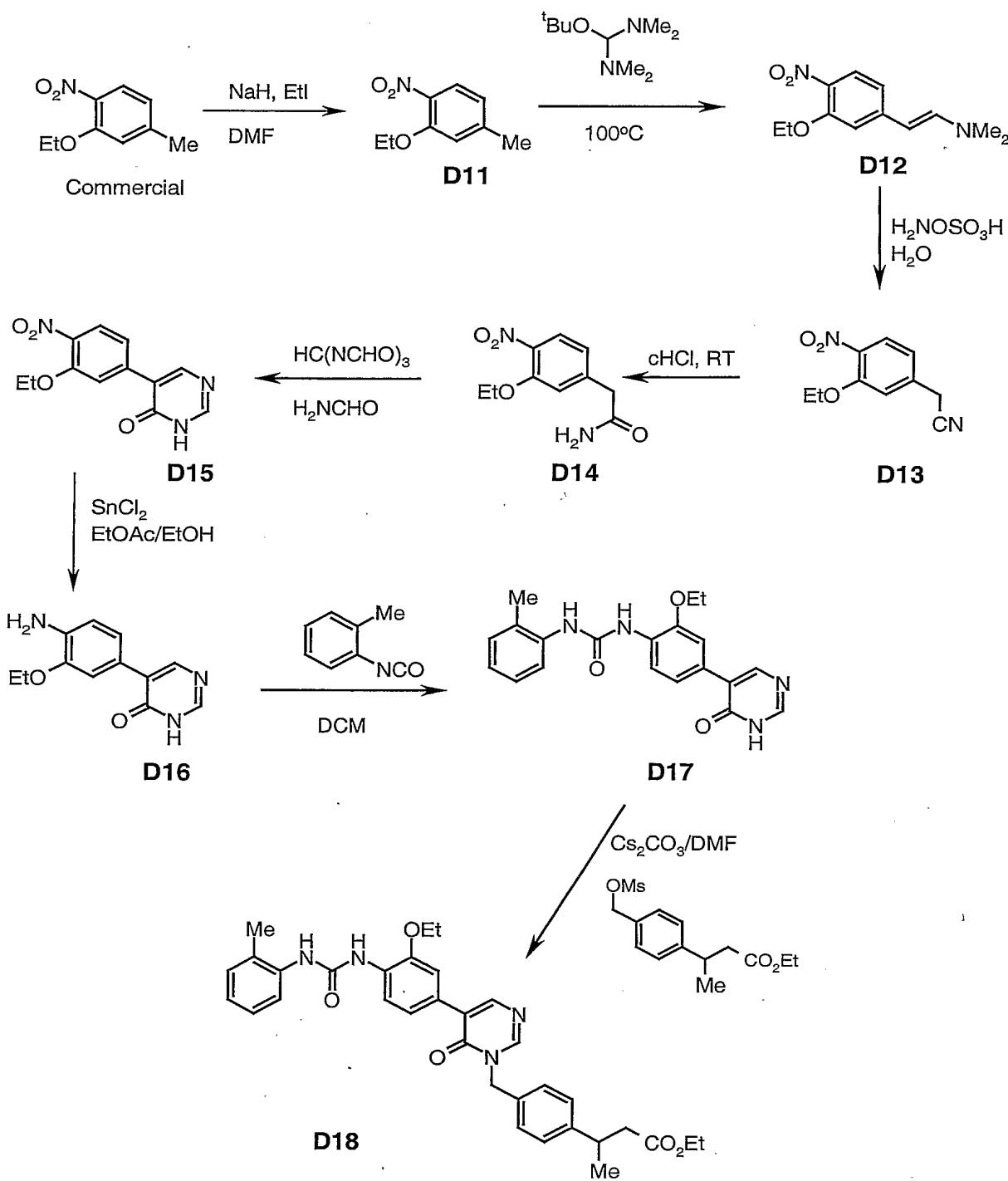
(*R,S*)-3-(4-{5-[3-Ethoxy-4-(3-*o*-tolyl-ureido)phenyl]-6-oxo-6*H*-pyrimidin-1-

ylmethyl}phenyl)butyric acid ethyl ester (D18)

(*R,S*)-3-(4-Methanesulfonyloxymethylphenyl)butyric acid ethyl ester (prepared from (*R,S*)-3-(4-hydroxymethylphenyl)butyric acid ethyl ester (D5) by a method analogous to that described for D10, 495 mg, 1.5 mmol) was stirred under argon in dimethylformamide (20 mL). 1-[2-Ethoxy-4-(6-oxo-1,6-dihydro-pyrimidin-5-yl)phenyl]-3-*o*-tolyl-urea (D17, 400 mg, 1.1 mmol) and cesium carbonate (716 mg, 2.2 mmol) were added and the mixture was 35

stirred for 16 hours. The mixture was diluted with ethyl acetate (20 mL) and water (20 mL) and after separation of the organic layer, the aqueous phase was re-extracted with ethyl acetate (2 x 20 mL). The combined organic layers were washed with brine (20 mL), dried over magnesium sulfate, filtered and concentrated at reduced pressure. The crude product
5 was purified by silica gel chromatography (Flashmaster II, 50 g silica) eluting with ethyl acetate:hexane (66:34) to yield the title compound as a colourless solid; LC/MS (AP+ve): $[M+H]^+$ at m/z 569 ($C_{33}H_{36}N_4O_5$ requires $[M+H]^+$ at m/z 569).

Descriptions D11 - D18 are represented by the following reaction scheme.



Description 19

5 **(R)-3-[4-[5-(4-Nitrophenyl)-6-oxo-6H-pyrimidin-1-ylmethyl]phenyl]butyric acid methyl ester (D19)**

To a solution of 5-(4-nitrophenyl)-3H-pyrimidinone (400 mg, 1.8 mmol) {Tsatsaronis *et al.*, Chem. Ber., 94, 1961, 2876} in dimethylformamide (7 mL) was added cesium

carbonate (1.2 g, 3.6 mmol) followed by a solution of (*R*)-3-(4-methanesulfonyloxymethylphenyl)butyric acid methyl ester (D10, ~1.8 mmol) in dimethylformamide (3 mL). The reaction was stirred at room temperature for 2 hours and then diluted with ethyl acetate. After separation of the organic layer the aqueous phase 5 was further extracted with ethyl acetate. The combined organic layers were dried over magnesium sulfate, filtered and concentrated *in vacuo*. The crude product was purified by chromatography on silica gel eluting with 60:40 ethyl acetate:hexane to yield the title compound as a solid; MS (APCI+ve): $[M+H]^+$ at m/z 408 ($C_{22}H_{21}N_3O_5$ requires $[M+H]^+$ at m/z 408).

10 Description 20

(*R*)-3-{4-[5-(4-Aminophenyl)-6-oxo-6*H*-pyrimidin-1-ylmethyl]phenyl}butyric acid methyl ester (D20)

To a solution of (*R*)-3-{4-[5-(4-nitrophenyl)-6-oxo-6*H*-pyrimidin-1-ylmethyl]phenyl}butyric acid methyl ester (D19, 420 mg, 1.03 mmol) in 1:1 ethyl acetate:ethanol (30 mL) was added tin (II) chloride dihydrate (1.2 g, 5.30 mmol). The 15 reaction mixture was heated at 80°C for 2 hours and then allowed to cool to room temperature. Saturated aqueous sodium hydrogen carbonate (20 mL) was added and the resulting precipitate removed by filtration. The product was extracted into ethyl acetate, dried over magnesium sulfate, filtered and concentrated *in vacuo*. The residue was 20 purified by chromatography on silica gel eluting with 70:30 ethyl acetate:hexane to yield the title compound as a foam; MS (APCI+ve): $[M+H]^+$ at m/z 378 ($C_{22}H_{23}N_3O_3$ requires $[M+H]^+$ at m/z 378).

Description 21

(*R*)-3-(4-{6-Oxo-5-[4-(3-*o*-tolyl-ureido)phenyl]-6*H*-pyrimidin-1-ylmethyl}phenyl)butyric acid methyl ester (D21)

To a solution of (*R*)-3-{4-[5-(4-aminophenyl)-6-oxo-6*H*-pyrimidin-1-ylmethyl]phenyl}butyric acid methyl ester (D20, 360 mg, 0.95 mmol) in dichloromethane (10 mL) was added *o*-tolylisocyanate (0.18 mL, 1.45 mmol). The reaction was stirred at room temperature for 14 hours and then concentrated *in vacuo*. The crude product was 30 purified by chromatography on silica gel eluting with 70:30 ethyl acetate:hexane to yield the title compound as a colourless foam. MS (ES+ve): $[M+H]^+$ at m/z 511 ($C_{30}H_{30}N_4O_4$ requires $[M+H]^+$ at m/z 511).

Description 22

3-(4-Aminophenyl)-1*H*-pyrazin-2-one (D22)

3-Phenyl-1*H*-pyrazin-2-one (4.3 g, 25 mmol, prepared by the method of G Karmas and P.E. Spoerri, J. Amer. Chem. Soc., 1956, 78, 4071) was added portion-wise with stirring to a mixture of concentrated sulphuric acid (5 mL) and fuming nitric acid (15 mL) pre-cooled to -40°C, keeping the temperature below -30°C during the addition. The reaction mixture 5 was stirred for a further hour, gradually warming to 0°C, and then poured into stirring ice/water (125 mL). A mixture of nitro isomers was obtained after collection of the resulting solid, washing with water and drying *in vacuo*. The required 3-(4-nitrophenyl)-1*H*-pyrazin-2-one isomer can be obtained from this mixture as the first crop by fractional crystallization from acetone. Hydrogenation (10%Pd/C, 50 psi) in ethanol/water afforded 10 the title compound as a solid; MS (AP+ve): $[M+H]^+$ at m/z 188 ($C_{10}H_9N_3O$ requires $[M+H]^+$ at m/z 188).

Further product was obtained by hydrogenation of the second crop material and separation of the resulting isomers by chromatography on silica gel eluting with 1:3 methanol/sat. ammonia: dichloromethane, the title compound eluting first.

15 **Description 23**

4-(1-Benzylloxycarbonylmethylenepropyl)benzoic acid methyl ester (D23)

A solution of (dimethoxyphosphoryl)acetic acid benzyl ester (6.7 g, 25.9 mmol) in dry dimethylformamide (20 mL) was added dropwise with stirring under argon to an ice-bath cooled suspension of sodium hydride (1.1 g, 60% dispersion in oil, 27.5 mmol) in dry 20 dimethylformamide (60 mL), and then the mixture stirred at room temperature for 30 minutes. A solution of 4-propanoylbenzoic acid methyl ester (5.0 g, 26.0 mmol) in dry dimethylformamide (20 mL) was added and stirring continued overnight at room temperature. The mixture was concentrated under reduced pressure and then partitioned between ethyl acetate (100 mL) and water containing 10% acetic acid (50 mL). The 25 aqueous layer was further extracted with ethyl acetate (2x100 mL) and the combined organic layers washed with brine (50 mL), dried over anhydrous magnesium sulfate, filtered and evaporated to dryness. Purification by column chromatography on silica gel with a gradient of 15-30% ethyl acetate in hexane gave a mixture of *E* and *Z* isomers of the title compound together with the double bond positional isomer 4-((*E*)-1-30 benzyloxycarbonylmethyl(propenyl)benzoic acid methyl ester. This mixture was carried forward without further purification.

Description 24

(*R,S*)-4-(1-Carboxymethylpropyl)benzoic acid methyl ester (D24)

35 The mixture of double bond isomers including 4-(1-benzyloxycarbonylmethylenepropyl)benzoic acid methyl ester (D23, 3.37 g, 10.4 mmol) in

methanol (150 mL) with 10% palladium on charcoal was hydrogenated at atmospheric pressure and room temperature for 5 hours. After filtration through a pad of celite and washing with further methanol the resulting solution was evaporated to dryness to give the product initially as a colourless oil that solidified on standing.

5

Description 25

4-{(S)-1-[((S)-2-Hydroxy-1-phenylethylcarbamoyl)methyl]propyl}benzoic acid methyl ester (D25a) and 4-{(R)-1-[((S)-2-Hydroxy-1-phenylethylcarbamoyl)methyl]propyl}benzoic acid methyl ester (D25b)

10 The title compounds were prepared from (*R,S*)-4-(1-carboxymethylpropyl)benzoic acid methyl ester (D24) by a procedure analogous to the method of Description 6.

The diastereomeric products were separated by column chromatography on silica gel with ethyl acetate and then 5-10% methanol in ethyl acetate as eluant.

15 Early fractions contained 4-{(S)-1-[((S)-2-hydroxy-1-phenylethylcarbamoyl)methyl]propyl}benzoic acid methyl ester (D25a) as a white solid; MS (ES+ve): [M+H]⁺ at m/z 356 ($C_{21}H_{25}NO_4$ requires [M+H]⁺ at m/z 356).

20 Later fractions contained 4-{(R)-1-[((S)-2-hydroxy-1-phenylethylcarbamoyl)methyl]propyl}benzoic acid methyl ester (D25b) as a white solid; MS (ES+ve): [M+H]⁺ at m/z 356 ($C_{21}H_{25}NO_4$ requires [M+H]⁺ at m/z 356).

Description 26

(S)-3-(4-Hydroxymethylphenyl)pentanoic acid ((S)-2-hydroxy-1-phenylethyl) amide (D26a) and (R)-3-(4-Hydroxymethylphenyl)pentanoic acid ((S)-2-hydroxy-1-phenylethyl) amide (D26b)

25 The later eluting diastereomer 4-{(R)-1-[((S)-2-hydroxy-1-phenylethylcarbamoyl)methyl]propyl}benzoic acid methyl ester (D25b) was reduced to the title compound (*R*)-3-(4-hydroxymethylphenyl)pentanoic acid ((*S*)-2-hydroxy-1-phenylethyl) amide (D26b) with lithium borohydride by the method of Description 7; MS (ES-ve): [M-H]⁻ at m/z 326 ($C_{20}H_{25}NO_3$ requires [M-H]⁻ at m/z 326).

30 The other diastereomer, (*S*)-3-(4-hydroxymethylphenyl)pentanoic acid ((*S*)-2-hydroxy-1-phenylethyl) amide (D26a) was prepared in an analogous fashion from the earlier eluting diastereomer 4-{(S)-1-[((S)-2-hydroxy-1-phenylethylcarbamoyl)methyl]propyl}benzoic acid methyl ester (D25a); MS (ES-ve): [M-H]⁻ at m/z 326 ($C_{20}H_{25}NO_3$ requires [M-H]⁻ at m/z 326).

35

Description 27

(R)-3-(4-Hydroxymethylphenyl)pentanoic acid (D27)

A solution of (R)-3-(4-hydroxymethylphenyl)pentanoic acid ((S)-2-hydroxy-1-phenylethyl) amide (D26b, 2.93 g, 8.24 mmol) in dioxane (120 mL) and 3N sulfuric acid (120 mL) was heated at reflux for 5 hours, cooled and concentrated under reduced pressure. After extraction with ethyl acetate (3x100 mL) the combined organic layers were washed with 5 water (50 mL) followed by brine (50 mL) and then dried over anhydrous magnesium sulfate. The title compound was obtained after filtration and evaporation to dryness.

Description 28

(S)-3-(4-Hydroxymethylphenyl)pentanoic acid (D28)

10 The title compound was prepared in the same manner as the corresponding (R) isomer (D27) from (S)-3-(4-hydroxymethylphenyl)pentanoic acid ((S)-2-hydroxy-1-phenylethyl) amide (D26a). MS (ES-ve): $[M-H]^-$ at m/z 207 ($C_{12}H_{16}NO_3$ requires $[M-H]^-$ at m/z 207).

Description 29

(R)-(-)-3-(4-Hydroxymethylphenyl)pentanoic acid methyl ester (D29)

15 A solution of (R)-3-(4-hydroxymethylphenyl)pentanoic acid (D27, 2.0 g, 9.6 mmol) in methanol (150 mL) and concentrated sulfuric acid (3 mL) was heated at reflux for 1.5 hours and then cooled, concentrated under reduced pressure and partitioned between ethyl acetate (100 mL) and water (100 mL). The aqueous layer was further extracted with 20 ethyl acetate (2x50 mL) and the combined organic layers washed with brine (50 mL), dried over anhydrous magnesium sulfate, filtered and evaporated to dryness. After purification by column chromatography on silica gel with 1:1 ethyl acetate as eluant the title compound was obtained as a colourless oil; MS (ES+ve): $[M-OH]^+$ at m/z 205 ($C_{13}H_{18}O_3$ requires $[M-OH]^+$ at m/z 205); $[\alpha]_D^{30^\circ C} -30.7^\circ$ (c = 1.0, MeOH).

25

Description 30

(S)-(+)-3-(4-Hydroxymethylphenyl)pentanoic acid methyl ester (D29)

The title compound was prepared as a colourless oil from (S)-3-(4-hydroxymethylphenyl)pentanoic acid (D28) following the method of Description 29; MS 30 (ES+ve): $[M-OH]^+$ at m/z 205 ($C_{13}H_{18}O_3$ requires $[M-OH]^+$ at m/z 205); $[\alpha]_D^{30^\circ C} +31.4^\circ$ (c = 1.0, MeOH)

Description 31

(R)-3-(4-Methanesulfonyloxyethylphenyl)pentanoic acid methyl ester (D31)

The title compound was prepared from (R)-(-)-3-(4-hydroxymethylphenyl)pentanoic acid 35 methyl ester (D29) following the method of Description 10; MS (ES+ve): $[M-OMs]^+$ at m/z 205 ($C_{14}H_{20}O_5S$ requires $[M-OMs]^+$ at m/z 205).

Description 32

(R)-3-(4-[6-Oxo-5-[4-(3-o-tolyl-ureido)phenyl]-6H-pyridazin-1-ylmethyl]phenyl)pentanoic acid methyl ester (D32)

To 1-[4-(3-oxo-2,3-dihydropyridazin-4-yl)phenyl]-3-o-tolylurea (prepared from

5 4-(4-aminophenyl)-2H-pyridazin-3-one [described in EP 0138344] by the general method of Description 17) (341 mgs, 60% purity, 0.66 mmol) in dimethylformamide (6 mL) was added cesium carbonate (896 mg, 2.75 mmol) and (R)-3-(4-methanesulfonyloxymethylphenyl)pentanoic acid methyl ester (D31, 330 mg, 1.1 mmol) and the solution stirred for 16 hours at ambient temperature following the method of 10 Description 18. Ethyl acetate was added (50 mL), washed with water (2x50 mL) and the organic layer concentrated *in vacuo*. The compound was purified by silica chromatography with a linear gradient of 10-100% ethyl acetate in hexane. The appropriate fractions were combined to yield the title compound after evaporation to dryness; LC-MS (ES+ve): [M+H]⁺ at m/z 525 ($C_{31}H_{32}N_4O_4$ requires [M+H]⁺ at m/z 525)

15

Description 33

5-Chloro-4-(3-methoxyphenyl)-2H-pyridazin-3-one (D33)

A solution of 3-methoxyphenylmagnesium bromide in tetrahydrofuran (1M, 100 mL, 100 mmol) was slowly added to a stirred solution of 4,5-dichloro-2H-pyridazin-3-one (6.6 g, 40 mmol) in a mixture of tetrahydrofuran (30 mL) and diethyl ether (100 mL) cooled to 15°C. The mixture was stirred at room temperature for 30 minutes and then cooled in an ice bath. Saturated aqueous ammonium chloride (70 mL) was added slowly. The mixture was diluted with water and the solid collected by filtration. The solid was washed successively with dilute hydrochloric acid, water and diethyl ether, then dried under 25 vacuum. The combined filtrates were extracted with diethyl ether, washed with water, brine, dried over anhydrous magnesium sulfate, filtered and evaporated to dryness. This residue was crystallised from ethyl acetate to give a further batch of product as a white solid; MS (ES+ve): [M+H]⁺ at m/z 237/239 ($C_{11}H_9ClN_2O_2$ requires [M+H]⁺ at m/z 237/239).

30

Description 34

4-(3-Methoxyphenyl)-2H-pyridazin-3-one (D34)

5-Chloro-4-(3-methoxyphenyl)-2H-pyridazin-3-one (D33, 8.22 g, 34.7 mmol) was dissolved in a solution of sodium hydroxide (3.48 g, 87 mmol) in water (100 mL) and dimethylformamide (12 mL). 10% Palladium on carbon (0.3 g) was added and the mixture shaken under hydrogen (50 psi) at room temperature for 3 hours. 2M Sodium hydroxide was added to dissolve a precipitate and the filtered solution acidified with concentrated hydrochloric acid. The resulting white solid was collected by filtration, washed with water

and dried under vacuum to give the title compound; MS (ES+ve): $[M+H]^+$ at m/z 203 ($C_{11}H_{10}N_2O_2$ requires $[M+H]^+$ at m/z 203).

Description 35

5 **N-[2-Methoxy-4-(3-oxo-2,3-dihydropyridazin-4-yl)phenyl]acetamide (D35)**
4-(3-Methoxyphenyl)-2H-pyridazin-3-one (D34, 4.0 g, 19.8 mmol) was added portionwise to a stirred mixture of concentrated nitric acid (16 mL) and concentrated sulfuric acid (1.6 mL) at 15°C. The mixture was stirred at room temperature for 4 hours then added to a rapidly stirred ice-water mixture (300 mL). The pale yellow solid was collected by 10 filtration, washed with water and dried under vacuum to give a mixture of 4-(3-methoxy-2-nitrophenyl)-2H-pyridazin-3-one, 4-(3-methoxy-4-nitrophenyl)-2H-pyridazin-3-one, and 4-(5-methoxy-2-nitrophenyl)-2H-pyridazin-3-one; MS (ES+ve): $[M+H]^+$ at m/z 248 ($C_{11}H_9N_3O_4$ requires $[M+H]^+$ at m/z 248).

15 The mixture of nitro isomers obtained above (4.76 g) was dissolved in solution of sodium hydroxide (1.64 g, 41 mmol) in water (120 mL) and dimethylformamide (14 mL). 10% Palladium on carbon (0.2 g) was added and the mixture shaken under hydrogen (15 psi) at room temperature for 16 hours. 2M Sodium hydroxide (6 mL) was added to dissolve a precipitate, a further portion of 10% palladium on carbon (0.2 g) was added, and 20 hydrogenation was continued for a further 6 hours. The filtered solution was acidified to pH 2.0 by addition of concentrated hydrochloric acid. The solution was evaporated to dryness and the residue containing a mixture of 4-(2-amino-3-methoxyphenyl)-2H-pyridazin-3-one, 4-(4-amino-3-methoxyphenyl)-2H-pyridazin-3-one and 4-(2-amino-5-methoxyphenyl)-2H-pyridazin-3-one was dried under vacuum at 40°C overnight.

25 The above mixture was dissolved in water (350 mL), sodium acetate trihydrate (30 g) was added and the mixture cooled in an ice bath. Acetic anhydride (25 mL) was added. After 10 minutes the ice bath was removed and stirring was continued for a further 30 minutes. The mixture was evaporated to dryness and the residue was extracted with a 30 dichloromethane/methanol mixture (9:1, 250 mL). The extract was partially purified by chromatography (silica gel, 5-10% methanol in dichloromethane) to give, in order of elution: N-[2-methoxy-4-(3-oxo-2,3-dihydropyridazin-4-yl)phenyl]acetamide, N-[4-methoxy-2-(3-oxo-2,3-dihydro-pyridazin-4-yl)-phenyl]-acetamide and N-[2-methoxy-6-(3-oxo-2,3-dihydro-pyridazin-4-yl)-phenyl]-acetamide. Crystallisation of the earliest eluting 35 isomer from ethyl acetate gave pure N-[2-methoxy-4-(3-oxo-2,3-dihydropyridazin-4-yl)phenyl]acetamide; MS (ES+ve): $[M+H]^+$ at m/z 260 ($C_{13}H_{13}N_3O_3$ requires $[M+H]^+$ at m/z 260).

Description 36

4-(4-Amino-3-methoxyphenyl)-2*H*-pyridazin-3-one (D36)

A mixture of N-[2-methoxy-4-(3-oxo-2,3-dihydropyridazin-4-yl)phenyl]acetamide (D35, 0.42 g) and 6M hydrochloric acid (20 mL) was heated under reflux for 30 minutes. After

5 cooling and concentrating, the residue was dissolved in dilute sodium hydroxide. Dilute hydrochloric acid was added to pH 5-6 with ice bath cooling. The resulting solid was collected by filtration, washed with cold water and dried under vacuum to give the title compound; MS (ES+ve): $[M+H]^+$ at m/z 218 ($C_{11}H_{11}N_3O_2$ requires $[M+H]^+$ at m/z 218).

10 **Description 37**

2-Methoxy-3-(3-methoxy-4-nitrophenyl)pyrazine (D37)

2,2,6,6-Tetramethylpiperidine (0.71 mL, 4.21 mmol) was added to a solution of *n*-butyllithium (1.6M, 2.6 mL, 4.16 mmol) in tetrahydrofuran (10 mL) at -30°C. The mixture was allowed to warm up to 0°C and stirred at that temperature for 15 minutes. The

15 solution was then cooled to -70°C, a solution of 2-methoxypyrazine (200 mg, 1.80 mmol) in tetrahydrofuran (5 mL) was added and then the mixture stirred at that temperature for 30 minutes. A solution of zinc chloride (500 mg, 3.67 mmol) in tetrahydrofuran (5 mL) was subsequently added at -70°C and the mixture was then allowed to warm slowly to room temperature. A solution containing tetrakis(triphenylphosphine)palladium (0) (83

20 mg, 0.07 mmol) and 4-bromo-2-methoxy-1-nitrobenzene (459 mg, 1.98 mmol) in tetrahydrofuran (5 mL) was added to the organozinc derivative and the mixture heated at 65°C for 2 hours. The reaction mixture was then hydrolysed with a solution containing ethylenediaminetetraacetic acid (1.1 g, 3.7 mmol) in water (10 mL) which had been made slightly basic with a saturated aqueous solution of potassium carbonate. The aqueous 25 phase was extracted with dichloromethane (3x100 mL) and the combined extracts dried over magnesium sulfate and concentrated *in vacuo*. The product was purified by silica gel chromatography eluting with 0 to 80% ethyl acetate in hexane to yield the title compound as a solid; MS (APCI+ve): $[M+H]^+$ at m/z 262 ($C_{12}H_{11}N_3O_4$ requires $[M+H]^+$ at m/z 262).

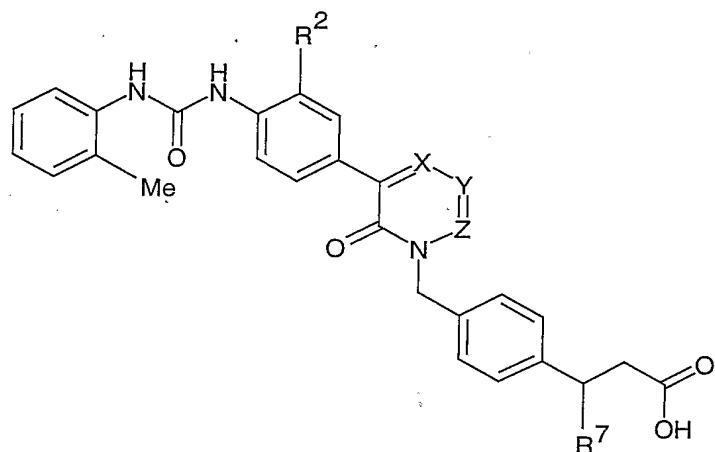
30 **Description 38**

3-(3-Methoxy-4-nitrophenyl)-1*H*-pyrazin-2-one (D38)

Thionyl chloride (2 mL) was added to a solution of 2-methoxy-3-(3-methoxy-4-nitrophenyl)pyrazine (D37, 340 mg, 1.30 mmol) in ethanol (10 mL). The reaction mixture was heated to reflux for 24 hours and then concentrated *in vacuo* to yield the title

35 compound as a solid; MS (APCI+ve): $[M+H]^+$ at m/z 248 ($C_{11}H_9N_3O_4$ requires $[M+H]^+$ at m/z 248).

Examples



Compound	X	Y	Z	R ²	R ⁷	Calc. Mass M	Observed [M+H] ⁺
E1	N	CH	CH	H	(R)-Me	496.571	497
E2	N	CH	CH	H	(R)-Et	510.598	511
E3	CH	N	CH	H	H	482.544	483
E4	CH	N	CH	H	(R)-Me	496.571	497
E5	CH	N	CH	H	(R)-Et	510.598*	511
E6	CH	N	CH	H	(S)-Et	510.598*	511
E7	CH	N	CH	MeO	(R)-Me	526.597	527
E8	CH	N	CH	MeO	(S)-Me	526.597	527
E9	CH	N	CH	EtO	(R,S)-Me	540.624	541
E10	CH	CH	N	H	(R)-Me	496.571	497
E11	CH	CH	N	H	(R)-Et	510.598*	511
E12	CH	CH	N	H	(S)-Et	510.598	511
E13	CH	CH	N	MeO	(R)-Me	526.597	527

E14	N	CH	CH	MeO	(R)-Me	526.597	527
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*Compounds prepared as Na salt: calculated mass of parent acid shown

The above tabulated compounds E1 - E14 were prepared using the methodology

5 described below.

Example 9

(R,S)-3-(4-{5-[3-Ethoxy-4-(3-*o*-tolyl-ureido)phenyl]-6-oxo-6*H*-pyrimidin-1-ylmethyl}phenyl)butyric acid (E9)

10 A solution of (R,S)-3-(4-{5-[3-ethoxy-4-(3-*o*-tolyl-ureido)phenyl]-6-oxo-6*H*-pyrimidin-1-ylmethyl}phenyl)butyric acid ethyl ester (D18, 348 mg, 0.61 mmol) in tetrahydrofuran (16 mL) was treated with 0.5N aqueous lithium hydroxide solution (13 mL). The reaction mixture was stirred for 16 hours and then acidified with 2N hydrochloric acid. The residue was diluted with ethyl acetate (20 mL) and after separation of the organic layer, the 15 aqueous phase was re-extracted with ethyl acetate (2 x 20 mL). The combined organic layers were dried over magnesium sulfate, filtered and concentrated at reduced pressure to yield the title compound as a colourless solid; ¹H NMR δ (DMSO-d6): 1.18 (3H, d), 1.41 (3H, t), 2.27 (3H, s), 2.46 (2H, m), 3.15 (1H, m), 4.18 (2H, q), 5.15 (2H, s), 6.97 (1H, ap. t), 7.15 (1H, ap. t), 7.18 (1H, d), 7.27 (5H, m), 7.42 (1H, d), 7.71 (1H, d), 8.13 (1H, d), 8.19 (1H, s), 8.48 (1H, s), 8.63 (1H, s), 8.67 (1H, s), 12.05 (1H, br. s); LC/MS (ES+ve) [M+H]⁺ 20 at m/z 541 (C₃₁H₃₂N₄O₅ requires [M+H]⁺ at m/z 541).

The corresponding chiral methoxy substituted compounds **E7** and **E8** were prepared similarly to D14 - D18 starting from the known (3-methoxy-4-nitrophenyl)acetonitrile [PCT Int. Appl. WO 86/01204] except that the hydrolysis of acetonitrile to acetamide was 25 conducted over 16 hours instead of 48 hours.

Example 4

(R)-3-(4-{6-Oxo-5-[4-(3-*o*-tolyl-ureido)phenyl]-6*H*-pyrimidin-1-ylmethyl}phenyl)butyric acid (E4)

(R)-3-(4-{6-Oxo-5-[4-(3-*o*-tolyl-ureido)phenyl]-6*H*-pyrimidin-1-ylmethyl}phenyl)butyric acid 30 methyl ester (D21, 380 mg, 0.75 mmol) in tetrahydrofuran (10 mL) was stirred with 0.5N lithium hydroxide (10 mL) for 3 hours at room temperature. The reaction mixture was acidified to pH 1 with 2N aqueous hydrochloric acid and extracted with ethyl acetate. The organic layer was dried over magnesium sulfate, filtered and concentrated *in vacuo* to

yield the title compound as a solid; MS (ES+ve): $[M+H]^+$ at m/z 497 ($C_{29}H_{28}N_4O_4$ requires $[M+H]^+$ at m/z 497); 1H NMR δ (DMSO-d6): 1.18 (3H, d), 2.24 (3H, s), 2.50 (2H, d), 3.14 (1H, q), 5.13 (2H, s), 6.93 (1H, t), 7.13 (2H, m), 7.25 (2H, d), 7.32 (2H, d), 7.50 (2H, d), 7.65 (2H, d), 7.85 (1H, d), 7.96 (1H, s), 8.12 (1H, s), 8.65 (1H, s), 9.16 (1H, s), 11.92 (1H, s).

5 **Compounds E1 and E2** were prepared from 3-(4-aminophenyl)-1*H*-pyrazin-2-one (D22) using methods analogous to those disclosed in relevant descriptions and examples herein. For example E1 is prepared by reaction of Description 22 with o-tolylisocyanate by the method of Description 17, the resulting pyrazinone then alkylated with (*R*)-3-(4-10 methanesulfonyloxymethylphenyl)butyric acid methyl ester (D10), and the resulting ester hydrolysed by the method of Example 9.

10 **Compounds E10 - E12** are prepared from 4-(4-aminophenyl)-2*H*-pyridazin-3-one [described in EP 0138344] in an analogous manner to that outlined for E1 above using the appropriate alkylating agents.

15 **Example 11**

(R)-3-(4-{6-Oxo-5-[4-(3-*o*-tolyl-ureido)phenyl]-6*H*-pyridazin-1-ylmethyl}phenyl)pentanoic acid sodium salt (E11)

To (R)-3-(4-{6-oxo-5-[4-(3-*o*-tolyl-ureido)phenyl]-6*H*-pyridazin-1-ylmethyl}phenyl)pentanoic acid methyl ester (D32) in tetrahydrofuran (5 mL) was added 0.5M lithium hydroxide (5 20 mL) and the solution stirred at ambient temperature for 3 hours. 10% Citric acid solution was added until pH 5 attained and the product extracted into ethyl acetate (2x50 mL) and then washed with water (50 mL, x2). The organic layer was concentrated and then purified by chromatography on silica gel with a linear gradient of 0-10% methanol in dichloromethane as eluant. The appropriate fractions were combined and the solution 25 concentrated. Sodium hydroxide (2M, 93 μ L, 1 equiv.) was added and the solution concentrated again to yield the title compound as a white solid; LC-MS (ES+ve): $[M+H]^+$ at m/z 511 ($C_{30}H_{30}N_4O_4$ (free acid) requires $[M+H]^+$ at m/z 511); 1H NMR (DMSO-d6): 0.67 (3H, t), 1.44 (1H, m), 1.67 (1H, m), 2.16 (1H, dd), 2.22 (1H, d), 2.24 (3H, s), 2.93 (1H, m), 5.24 (1H, d), 5.30 (1H, d), 6.93 (2H, dd), 7.11 (1H, dd), 7.14 (1H, d), 7.15 (2H, d), 30 7.23 (2H, d), 7.53 (2H, d), 7.59 (2H, d), 7.62 (1H, d), 7.81 (1H, d), 7.92 (1H, d), 9.84 (1H, br. s), 11.12 (1H, br. s).

Other chiral ethyl substituted **compounds E2, E5, E6, and E12** were prepared in analogous manner to compound E11.

Example 13

(R)-3-(4-{5-[3-Methoxy-4-(3-o-tolyl-ureido)phenyl]-6-oxo-6H-pyridazin-1-ylmethyl}phenyl)butyric acid (E13)

The title compound is prepared from D36 by firstly reaction with *o*-tolylisocyanate by the method of Description 17 to give 1-[2-methoxy-4-(3-oxo-2,3-dihydro-pyridazin-4-yl)-phenyl]-3-*o*-tolyl-urea, then alkylation with the mesylate D10 by the general method of Description 18 to give (R)-3-(4-{5-[3-methoxy-4-(3-*o*-tolyl-ureido)phenyl]-6-oxo-6H-pyridazin-1-ylmethyl}phenyl)butyric acid methyl ester.

(R)-3-(4-{5-[3-Methoxy-4-(3-*o*-tolyl-ureido)phenyl]-6-oxo-6H-pyridazin-1-ylmethyl}phenyl)butyric acid methyl ester

84 mg, 0.155 mmol) in tetrahydrofuran (5 mL) was then treated with 0.5M lithium hydroxide (7 mL) and stirred at room temperature for 6.5 hours, then product isolated by the method of Example 9; MS (ES+ve): [M+H]⁺ at m/z 527 (C₃₀H₃₀N₄O₅ requires [M+H]⁺ at m/z 262); ¹H NMR (DMSO-d₆): 1.18 (3H, d), 2.26 (3H, s), 2.47 (2H, obscured by solvent), 3.11 (1H, m), 3.94 (3H, s), 5.30 (2H, s), 6.96 (1H, t), 7.12-7.28 (7H, m), 7.52 (2H, dd), 7.66 (2H, m), 7.80 (1H, d), 8.00 (2H, d), 8.23 (1H, d), 8.61 (1H, s), 8.83 (1H, s), 12.06 (1H, s).

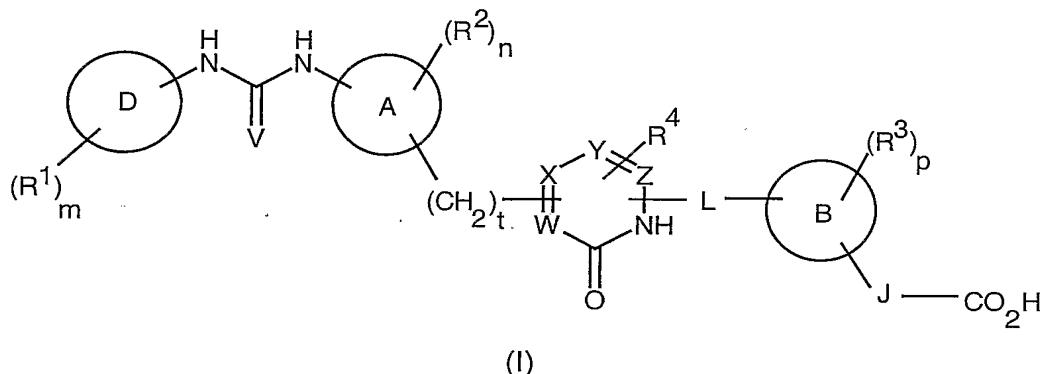
Example 14

(R)-3-(4-{3-[3-methoxy-4-(3-*o*-tolyl-ureido)phenyl]-2-oxo-2H-pyrazin-1-ylmethyl}phenyl)butyric acid (E14)

The title compound was prepared from D38 by analogous procedures to those described herein, i.e. 3-(3-methoxy-4-nitrophenyl)-1*H*-pyrazin-2-one (D38) is converted (R)-3-{4-[3-(3-methoxy-4-nitrophenyl)-2-oxo-2*H*-pyrazin-1-ylmethyl]phenyl}butyric acid methyl ester by the method of Description 19; reduced to (R)-3-{4-[3-(4-amino-3-methoxyphenyl)-2-oxo-2*H*-pyrazin-1-ylmethyl]phenyl}butyric acid methyl ester by the method of Description 20. This amine is then converted to the urea (R)-3-(4-{3-[3-methoxy-4-(3-*o*-tolyl-ureido)phenyl]-2-oxo-2*H*-pyrazin-1-ylmethyl}phenyl)butyric acid methyl ester by the method of Description 21 and finally hydrolysis of the methyl ester by the method of Example 4 affords the title compound.

CLAIMS

1. A compound of formula (I) or a pharmaceutically acceptable derivative thereof:



wherein

A, B and D are independently aryl or heteroaryl;

R¹, R² and R³ are independently C₁-6alkyl, halogen, C₁-6alkoxy, hydroxy, cyano, CF₃,

10 OCF₃, nitro, C₁-6alkylthio, amino, mono- or di-C₁-6alkylamino, carboxy, C₁-6alkanoyl, amido, mono or di-C₁-6alkyl amido, NHCOR⁹ or NHSO₂R⁹ in which R⁹ is C₁-6alkyl, C₃-7cycloalkyl or phenyl (optionally substituted by up to three groups selected from C₁-6alkyl, halogen, C₁-6alkoxy, cyano, phenyl and CF₃) or is a group -E-(CH₂)₁-6NR^XRY in which E is a single bond or -OCH₂- and R^X and R^Y are independently hydrogen, C₁-6alkyl or combine together to form a 5 - 7 membered heterocyclic ring;

15 R⁴ is hydrogen, C₁-6alkyl, halogen or C₁-6alkoxy;

V is O, S, NH, N-C₁-6alkyl, NNO₂ or NCN;

W, X, Y and Z are independently C, CH or N, subject to the proviso that at least one of X, Y and Z is N;

20 L is -(CH₂)_q- or -(CH₂)_q'O- where q is 0, 1, 2 or 3 and q' is 2 or 3;

J is (i) a group -CR⁵ = CR⁶- where R⁵ and R⁶ are independently hydrogen or C₁-6alkyl;

(ii) a group -CHR⁷-CHR⁸- where R⁷ and R⁸ are independently hydrogen,

25 C₁-6alkyl, C₃-7cycloalkyl, aryl, heteroaryl, a group -NHCOR⁹- or -NHSO₂R⁹- in which R⁹ is as defined above or a group -(CH₂)₁-6NR^XRY- in which R^X and R^Y are as defined above;

(iii) a single bond;

(iv) -CHR⁶- where R⁶ is as defined above; or

(v) a group -O-CHR¹⁰-, -NR¹¹-CHR¹⁰- or -CR¹²R¹³-CHR¹⁰- where R¹⁰ and R¹¹ are independently hydrogen or C₁-6alkyl and R¹² and R¹³ are

independently C₁-6alkyl or R¹² and R¹³ combine together to form a C₃-7cycloalkyl or or a 5 - 7 membered heterocyclic ring;

m, n and p are independently 0, 1, 2 or 3; and

t is 0, 1 or 2.

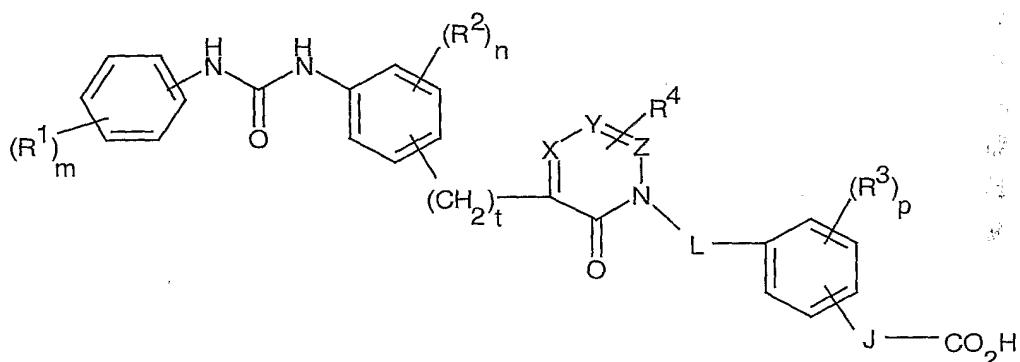
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2. A compound or a pharmaceutically acceptable derivative thereof according to claim 1, wherein A is phenyl or pyridyl.

10 3. A compound or a pharmaceutically acceptable derivative thereof according to claim 1 or 2, wherein B is phenyl.

4. A compound or a pharmaceutically acceptable derivative thereof according to any of the preceding claims, wherein D is phenyl or pyridyl.

15 5. A compound according to claim 1, wherein the compound is of formula (Ia) or a pharmaceutically acceptable derivative thereof:



(Ia)

20 in which:

R¹ - R⁴, L, J, X, Y, Z, m, n, p and t are as defined in formula (I).

25 6. A compound or a pharmaceutically acceptable derivative thereof according to any of the preceding claims in which R¹, R² and R³ are, independently, selected from the group consisting of C₁-6alkyl, halogen, C₁-6alkoxy, cyano or CF₃.

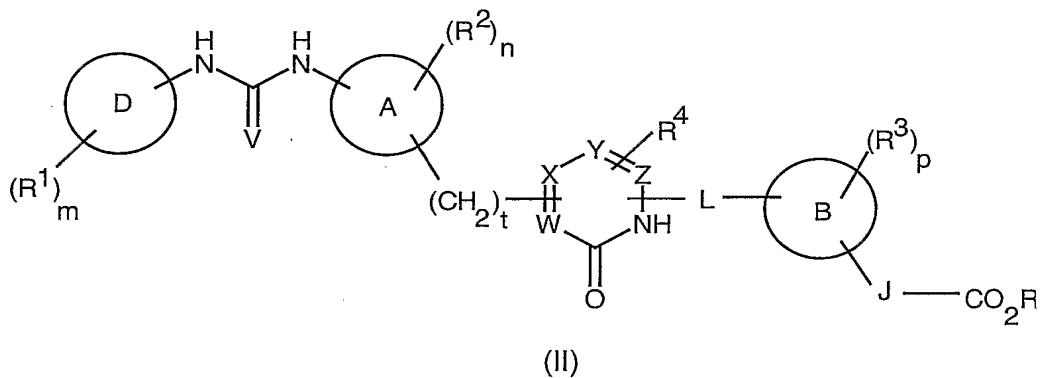
7. A compound or a pharmaceutically acceptable derivative thereof according to any of the preceding claims in which J is selected from the group consisting of -CH = CH-, - (CH₂)₂- and -CHR⁷-CH₂- in which R⁷ is C₁-6alkyl.

30

8. A compound or a pharmaceutically acceptable derivative thereof according to any of the preceding claims in which L is $-(CH_2)_q-$ where q is 0, 1, 2 or 3.

5 9. A compound or a pharmaceutically acceptable derivative thereof according to claim 1 which is selected from the group consisting of E1 - E12 or a pharmaceutically acceptable derivative thereof.

10. 10. A process for the preparation of a compound of formula (I) or a pharmaceutically acceptable derivative thereof which comprises hydrolysis of a carboxylic acid ester derivative of formula (II):



15 in which $\text{R}^1 - \text{R}^4$, m, n, p, t, A, B, D, L, J, V, W, X, Y and Z are as defined in formula (I) and R is a group capable of forming a carboxylic acid ester and optionally thereafter forming a pharmaceutically acceptable derivative thereof.

20 11. A compound or a pharmaceutically acceptable derivative thereof according to any one of claims 1 to 10 for use in therapy.

12. A pharmaceutical composition which comprises a therapeutically effective amount of a compound or a pharmaceutically acceptable derivative according to any one of claims 1 to 10 in admixture with a pharmaceutically acceptable carrier or diluent.

25 13. A pharmaceutical composition comprising a compound or a pharmaceutically acceptable derivative thereof according to any one of claims 1 - 10 or a pharmaceutically acceptable derivative thereof together with another therapeutically active agent.

30 14. The use of a compound or a pharmaceutically acceptable derivative thereof according to any one of claims 1 to 10 in the manufacture of a medicament for use in the

treatment or prophylaxis of conditions in which an inhibitor of α_4 integrin mediated cell adhesion is beneficial.

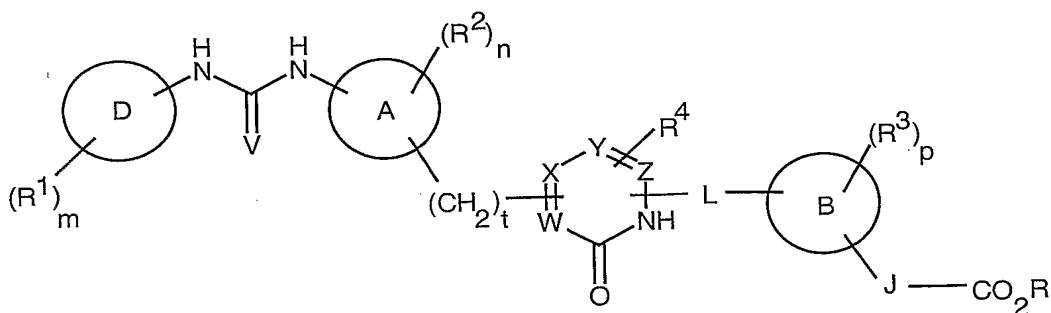
15. A method for the treatment or prophylaxis of conditions in which an inhibitor of α_4 integrin mediated cell adhesion is beneficial which comprises administering to a patient in need thereof a safe and effective amount of a compound or a pharmaceutically acceptable derivative thereof according to any one of claims 1 to 10.

16. The method according to claim 15, wherein said condition is selected from the group consisting of rheumatoid arthritis; asthma; allergic conditions; adult respiratory distress syndrome; AIDS-dementia; Alzheimer's disease; cardiovascular diseases; thrombosis or harmful platelet aggregation; reocclusion following thrombolysis; reperfusion injury; skin inflammatory diseases; diabetes; multiple sclerosis; systemic lupus erythematosus; inflammatory bowel disease; diseases associated with leukocyte infiltration to the gastrointestinal tract; diseases associated with leukocyte infiltration to epithelial lined tissues; pancreatitis; mastitis; hepatitis; cholecystitis; cholangitis or pericholangitis; bronchitis; sinusitis; inflammatory diseases of the lung; collagen disease; sarcoidosis; osteoporosis; osteoarthritis; atherosclerosis; neoplastic diseases; wound healing enhancement; eye diseases; Sjogren's syndrome; rejection after organ transplantation; host vs. graft or graft vs. host diseases; intimal hyperplasia; arteriosclerosis; reinfarction or restenosis after surgery; nephritis; tumor angiogenesis; malignant tumor; multiple myeloma and myeloma-induced bone resorption; sepsis, central nervous system injury and Meniere's disease.

25 17. The method according to claim 15, wherein said condition is asthma, allergic conditions, inflammatory bowel disease, rheumatoid arthritis, atopic dermatitis, multiple sclerosis or rejection after organ transplantation.

18. Compounds of formula (II)

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(II)

in which R^1 - R^4 , m, n, p, t, A, B, D, L, J, V, W, X, Y and Z are as defined in formula (I) and R is a group capable of forming a carboxylic acid ester.

ABSTRACT

The present invention relates to novel compounds, processes for their preparation, compositions comprising them and their use in the treatment of diseases capable of being
5 modulated by the inhibition of cell adhesion.

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